

Earth Science Partnership

Consulting Engineers | Geologists | Environmental Scientists

Factory Road, Newport
Proposed Residential Development
Geo-Environmental and Geotechnical Report
Report Reference: ESP.8159.3752 Rev2

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Factory Road, Newport Proposed Residential Development Geo-Environmental and Geotechnical Report

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Report Reference: **ESP.8159.3752 Rev2**

Revision	Status	Date	Written by	Checked by	Approved by
2	Final	November 2022	Alex Brabban BSc / Danilo Bettosi BSc MSc CGeol FGS CSci RoGEP Professional	Danilo Bettosi BSc MSc CGeol FGS CSci RoGEP Professional	Giles Sommerwill BSc MSc CGeol FGS RoGEP Specialist SiLC
2	Final	November 2022	Provision of updated report following completion of ground gas monitoring		
1	Final	August 2022	Provision of Final report including update following receipt of geotechnical results.		
0	Draft	August 2022	Provision of draft report for Client team comment.		
Signature:					
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Figure 1 – Investigation Point Plan

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Executive Summary

Interstrand Living Partnerships has purchased the subject site for redevelopment as a residential development. 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.	-	The site is currently disused and occupied by two vacant industrial buildings and external areas.
	Identified Ground Conditions.	-	The investigation has indicated the site to be underlain by a cover of Made Ground (in localised areas) followed by weathered St Maughans Group bedrock.
	Groundwater Conditions.	-	The site is underlain by a Secondary Aquifer with shallow groundwater encountered inconsistently.
	Historical Land Use.	-	The site is indicated to have been allotment gardens until the 1940s-1950s when the existing building was constructed. The onsite building comprises a manufacturing and warehousing use, however, surrounding land uses, include a nail factory, gasworks, infilled canal and allotment gardens.
Geo-environmental	Potential Contamination Sources	Moderate/ High	Site has been previously developed with former uses including allotments and works, with other land uses such as factories, works and a gas works in close proximity.
	Chronic Risks to Human Health	Moderate/ High	Generally low levels of potential contaminants have been identified, however some PAH contamination recorded, and large portions of the site not yet investigated. Asbestos was encountered in two locations and further assessment is recommended.
	Hazardous Ground Gas	Moderate/ Low	Environmental report indicates radon protection is required. Ground gas monitoring has indicated generally low levels, however, some pre-emptive protection recommended.
Geotechnical	Weak/Compressible Ground, requiring non-traditional foundations	Moderate/ Low	Conventional foundations may be suitable, subject to deepening in the north portion. Ground bearing slabs are likely suitable in the south portion, however, in the north they will need to be suspended or the area subject to an excavate and replace exercise. The above should be confirmed subject to recommended post demolition supplementary plasticity testing.
	Shrinkage or Swelling	Medium/High	Further plasticity testing should be undertaken.
	Sulphate Attack on Buried Concrete	Moderate/ Low	Generally low levels of sulphate noted, and design class DS-2/AC-2 recommended.
	Soakaway Feasibility	-	Unlikely to be suitable for use.
	UXO	-	A preliminary UXO report has identified that whilst always prudent, further assessment is not necessary.
	Flooding	Low	Available information indicates the site is not at risk of flooding from rivers or seas.
Others	Invasive Plants	-	No obvious evidence identified during site works.
	Further Investigation Required?	Yes	See Section 9.0.

Note: The above is intended to provide a brief summary of the conclusions of the assessment. It does not provide a definitive assessment and must not be referenced as a separate document. Refer to the main body of the report for details.

1 Introduction

1.1 Background

Interstrand Living Partnership (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 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 in Section 2.1.

We understand the outline proposed development comprises 48no. affordable housing units and flats with associated gardens and landscaped areas, however, we have not been provided with a copy of the proposed layout at this time. Based on the above, we understand that the proposed structures would be classified as Geotechnical Category 2 (BS5930:2015).

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. We are not aware of any ground hazard related planning conditions relating to the development.

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 windowless sample boreholes, trial pits, soakaway infiltration testing, geotechnical and geo-environmental laboratory testing, risks to human health 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 6th April 2022 (ref: db/8159.It1). This phase of works was undertaken whilst the on-site buildings and other features were still present and so is targeted at providing an Exploratory (preliminary) Assessment to aid in outline design.

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 8 – 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.

This report is issued as a digital version only.

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 above. 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. 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.

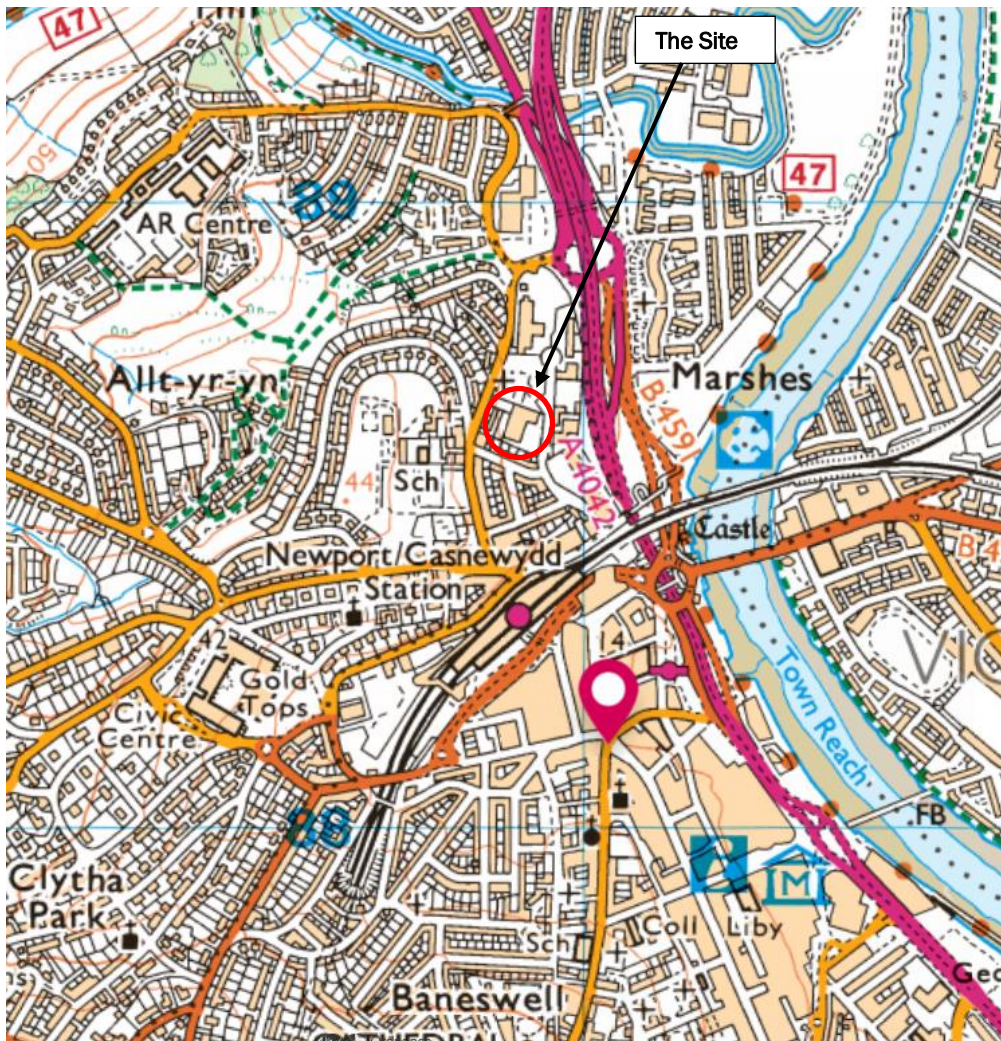
2 Desk Study and Field Reconnaissance Visit

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), a geological data report (Appendix D). Further desk study reports/data/records are included as subsequent appendices as referenced in the text.

The site description is largely based on a field reconnaissance and site inspection visit made at the site on 29th June 2022 during dry and sunny weather, and general views of the site are included as a series of photographs within the Plates section of this report.

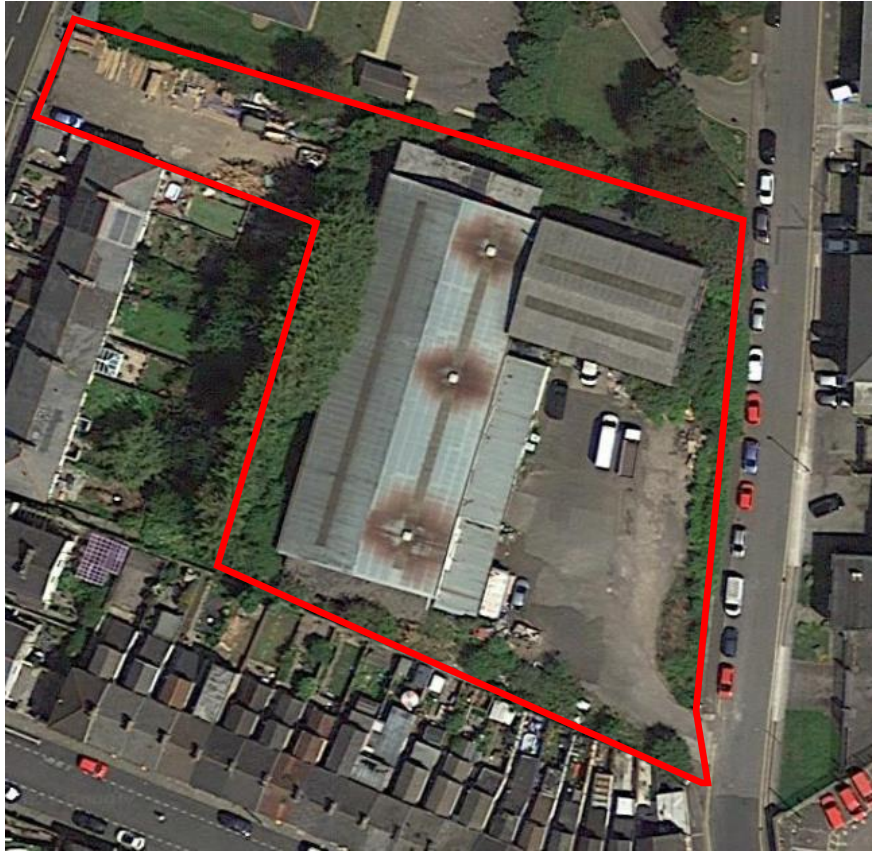
2.1 Site Location and Description

The site is located on the western side of Factory Road on the northern margins of Newport, Newport County. The National Grid Reference of the centre of the site is (ST) 330902 188646 and the postcode is NP20 5FA. A Site Location Plan is presented as Insert 1 below.



*Insert 1: Site Location Plan from Ordnance Survey 1:25,000 scale map.
Reproduced with permission (OS License No.: AL100015788).*

The site comprises a generally rectangular shaped parcel of land of around 65m length (north to south) and 50m width (east to west), with a narrow car park located in the north west of the site measuring 13m by 40m in size. With the site as a whole occupying an area of around 0.4ha. It is presently occupied by the existing Newpack warehouse (see Insert 2 below).



Insert 2: Current Site Layout (Google Earth 2022)

It is bounded by:

- To the north: Industrial units adjoining factory road including royal mail and BT.
- To the east: Industrial units adjoining factory road.
- To the south: Residential housing located along Lucas Street.
- To the west: Residential housing located along Queen's Hill Road.

Vehicular access to the site is currently gained via a gate on the south-eastern boundary. The boundaries generally comprise a combination of brick free-standing walls and post and wire fences.

Currently a large concrete floored warehouse and additional storage building occupy the majority of the site. No evidence for above or below ground tanks was noted during the walkover survey. However, due to the industrial use of the site the presence of these cannot be ruled out. While the site is overgrown with vegetation in a number of areas particularly around the site boundaries due to the sites lack of use, knotweed was not recorded on site.

We are not aware of a tree survey having been undertaken at this stage, but from site observations we have identified the trees on the west and eastern boundaries of the site to include willow. A tree survey should be completed by a specialist arboriculturist prior to development.

The general topography in the area is slopes towards the River Usk to the east. The site itself is situated at elevations ranging from around 16mAOD to 22mAOD. The car park area in the north west is located at the highest elevation and is around 6m higher in elevation than the main site area. A vegetated slope is also present along the north boundary (see Figure 1). Along the south boundary, ground levels reduce by around 1-2m, falling in height to Factory Road.

The Client has provided ESP with a series of plans showing the locations of recorded underground services in the vicinity of the site.

Site observations and the utility plans indicate that the site is crossed by the following services:

- Electricity cables on pylons across the southern area;
- A small substation, located on site (we understand from the client this is disconnected);
- A substation at the north boundary (off site);
- Storm and foul sewerage in the eastern and northern portions.



Insert 3: View of south portion (looking north)



Insert 4: View of north portion (looking south with rear of warehouse in background)

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 below.

It should be noted that on some of the mapping, some “wandering” of the site boundary is indicated, resulting in a slight displacement to the north. It is understood from the supplier that this reflects a referencing/scaling error due to modern scaling standards. The features discussed below are based on the correct site boundary where necessary.

Table 1: Review of Historical Maps

Date	On-Site	In Vicinity of Site
1880 – 1949	No major development noted on site. A series of liner features/fields are noted, which are identified as “allotment gardens” on later mapping.	Dos Nail Works located roughly 50m north. A slaughter house located 250m east, along with a gas works facility located 50m southeast. A rifle range is recorded 500m east of site. A large military barracks is recorded 600m west of site. The urban district of Baneswell is recorded to the south of site roughly 250m away at its closest point. Crindau Gas works, a large gas facility is indicated approximately 20m to the south. Monmouthshire Canal is indicated approximately 80m to the east.
1949 - 1985	A small earthwork/mound is noted in south portion from 1954. A Depot and Workshop noted on site in the 1970-1973 map	Dos nail works closed down between 1949 and 1963. Slaughter house closed down between 1965 and 1970. The gas works facility recorded 50m to the southeast as well as Crindau gas works still in operation. In 1970, the barracks located to the west is converted to a TA centre. Continued development of the Newport urban districts, the site is now surrounded with residential areas such as Barnardtown to the east and Crindau to the north. The canal is indicated to be disused after 1954 and partially infilled, and not indicated after 1970.
1985 - Present	Minor development to the workshop on site, adding the adjoining building in the northeast of site between 1985 and 1990. Workshop used as by Newpack exports following which the site was no longer in use.	Small Scale gas works to the southeast cease operation and facility demolished by 1990. Crindau gas works in operation until 2001. Continued development of Newport’s urban centres.
Notes to Table: 1. Extracts from historical maps presented in Appendix B. 2. Features may have been present on site between the dates of the individual mapping, and it should be appreciated that these cannot be identified from the map review.		

The site appears to have remained undeveloped until the 1970s when a depot and workshop were constructed. The site is located in an area of Newport that has been used for industrial purposes since the late 1800’s and so other previous, unrecorded developments on site cannot be ruled out.

2.2.2 Other Sources

No further relevant information on the site history has been identified as part of this assessment.

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.

2.2.4 Ecological Setting

An ecological assessment was not included within the brief, but we have not been advised of, or identified, any obvious evidence of any significant ecological features on the site.

2.3 Previous Investigations and Assessments

We are not aware of any previous geotechnical or geo-environmental investigations or assessments at the site.

2.4 Contact with Regulatory Bodies & Local Information Sources

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 Usk (classified as a Primary River) which flows from north to south approximately 250 m to the east. A number of streams are also present in the area, the closest of which lies some 40m to the south, and are classified as a Tertiary River (see Appendix C). The website of the Environment Agency (EA, 2022) indicates that the water quality within the River Usk has been marginal between good and moderate.

The environmental data report (Appendix C) indicates that the latest data shows the water quality (in terms of biology) in the River Usk was classified as Grade C (fair) in 2019. In terms of chemistry, the water quality over the same stretch of river was classed as Grade B (good) in 2019.

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 (Rivers and Seas)

From a review of topographical plans and flooding maps presented in the environmental data report/on the Natural Resources Wales website (NRW, 2022), 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. Nor does the site lie in an area at risk of flooding from surface water.

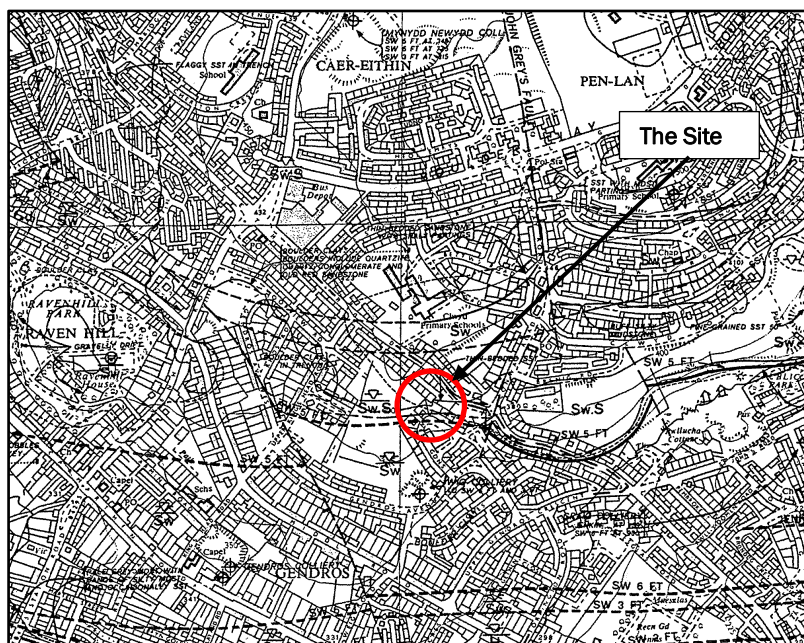
2.6 Geology

2.6.1 Published Geology

The published 1:50,000 scale geological map for the area of the site (Sheet 249, available on the website of the British Geological Survey, 2022) and the 1:10,560 scale sheet (SS68NW), indicate the site to be underlain by bedrock of the St Maughan's Group which comprise an interbedded succession of purple, brown and green sandstones and red mudstones with intraformational conglomerates.

No superficial deposits are indicated, however, due to historical development, a cover of Made Ground is likely to be present.

Reference to the up-to-date mapping available on the website of the British Geological Survey (BGS, 2022) indicates a similar succession.



*Insert 5: Extract from BGS Geological Map Sheet SS68NW, original 1:10,560 scale.
Reproduced with permission (BGS licence number: C15/05 CSL)*

2.6.2 Available BGS Borehole Records/Previous Investigation

Reference to the website of the British Geological Survey (BGS, 2022) indicates the available records of 2no. boreholes within 250m of the site. The borehole records indicate the following:

ST38NW-134: drilled some 180m to the east of the site this borehole indicated 0.2m of Topsoil underlain by 2.1m of Made Ground described as an orangey to reddish brown CLAY with concrete, slag and brick present. This was in turn underlain by 2.2m of weathered old red sandstone, with the borehole then terminating at 4.5m.

ST38NW-135: drilled some 245m to the east of the site this borehole indicated 0.3m of Topsoil underlain by 1.3m of Made Ground described as a dark brown to black CLAY. This was in turn underlain

by 1.4m of weak red brown Siltstone of the old red sandstone series. This was then underlain by 5.5m of stiff reddish brown Clay with the borehole then terminating at 8.7m.

2.7 Hydrogeology

2.7.1 Aquifer Classification

Reference to the aquifer maps published in the environmental data report (Appendix C) indicates that the bedrock (St Maughans Formation) is classed as Secondary A.

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.

2.7.2 Anticipated Groundwater Bodies

Based on the available information, we consider that the shallowest main groundwater body is likely to be located within the St Maughans Group bedrock. However, localised perched water bodies within overlying Made Ground cannot be discounted.

2.7.3 Abstractions and Groundwater Vulnerability

The environmental data report (Appendix C) indicates that there are no groundwater abstractions or Source Protection Zones within 500m of the site. The groundwater vulnerability shown in the environmental data report (Appendix C) is 'minor aquifer high'.

2.7.4 Groundwater Movement

Groundwater movement within the Made Ground will be controlled by intergranular flow whilst, in the bedrock, fracture flow is likely to be dominant.

2.7.5 Flooding (Groundwater)

The environmental data report presented (Appendix C) has identified a British Geological Survey (BGS) groundwater flooding susceptibility area within the site boundary as negligible.

2.8 Environmental Setting

2.8.1 Summary of Environmental Data

The site exists in a historically industrial, and now an industrial to 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 2 below and, where salient, discussed in Section 2.8.2.

Table 2: Summary of Environmental Data

Feature	On the Site	In the Immediate Vicinity
Environmentally Sensitive Sites ²	None identified.	1 recorded within 500m of the site.
Potentially Contaminative Land Use	2 identified.	12 recorded within 250m of the site, including a substation some 3m to the N.
Historical Tanks, PFS, Garages, Energy Facilities	2 identified.	46 recorded within 250m of the site.
Potentially Infilled Land	None identified in environmental data rpt	None recorded within 250m of the site.
IPPC Authorisations	None identified.	None recorded within 500m of the site.
Discharge Consents	None identified.	13 recorded within 500m of the site.
List 1 and 2 Dangerous Substances Sites	None identified.	1 recorded within 500m of the site.
Radioactive Substance Sites	None identified.	None recorded within 500m of the site.
Enforcements	None identified.	None recorded within 500m of the site.
Pollution Incidents	None identified.	5 recorded within 500m of the site.
Contaminated Land under Part 2A EPA 1990.	None identified.	None recorded within 500m of the site.
Waste Management Facilities	None identified.	1 recorded within 1km of the site.
Current Industrial/Commercial Sites	None identified.	1 recorded within 250m of the site.
Notes to Table: 1. Full details of features presented 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

Environmentally Sensitive Sites:

One is recorded within 500m of the site (east), this is listed as the River Usk due to water quality and habitat.

Pollution Incidents:

A total of five pollution incidents have occurred within 500m of the site. The closest of these was recorded 281m southeast of site and was a Category 3 (minor incident) where a pollutant was released to a watercourse in January 2017. The remaining incidents are also all recorded as Category 3 (Minor Incident) recorded 336m west, 391m south and 482m northeast. These events occurred in 2015, 2013 and 2003 respectively and all involved the release of pollutants into the water course.

Discharge Consents:

Thirteen are recorded within 500m of the site, the closest being some 245m to the east and related to the Civic Centre, this was for sewage discharge. However, this was revoked in 2014. The closest active discharge consent is located 457m north and is related to Malpas Brook on Barrack Hill, the discharge consent is also for sewage.

Potentially contaminative former land uses:

Two potentially contaminative former land uses are recorded on site, the first is related to the Dos Nail works and dates between 1882 and 1922. The second is an unspecified works recorded on site dating between 1963 and 1985. A number of other unspecified works are recorded immediately in the vicinity of the site including one 9m east of site. The remaining industrial land uses recorded within the immediate vicinity of the site are related to the previously discussed nail works, gas works and slaughter house.

Waste Management Facilities:

A unnamed scrap yard is recorded 413m north of the site. This scrap yard was in operation in 1970, however, little information is available regarding the yard.

Historical Tanks PFS, Garages, Energy Facilities:

Two historical energy features are located on site, these are listed as the electricity substation and transformer located along the north-western boundary of site, no tanks are recorded on site. The closest historical tanks are located 11m southeast of site within the small gasworks dating from 1883 to 1968. A total of fifteen historical tanks are recorded at that facility ranging in distance from 11m to 267m. Several historical energy features such as substations and gasometers are also related to the gas works with 7 energy features recorded between 11 and 134m southeast of site dating between 1883 and 1968.

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 various geotechnical and geomorphological hazards at the site is provided in the environmental data and geological data report (Appendix C). The potential hazards, as defined by the British Geological Survey (BGS) and reported in the above report are listed in Table 3 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 3: Preliminary Geotechnical Risk Register

Ground Stability Hazard	Potential ¹	ESP Comment
Coal Mining	The site is not located in an area of past coal mining	No further information identified to contradict data report.
Mining (non-coal)	The site is located in an area of past mining.	No further information identified to contradict data report.
Shrinking or Swelling Clays	Low	See Section 2.9.2
Landslides/ Slope Instability	Low	See Section 2.9.3
Ground Dissolution (Soluble Rocks)	Negligible	No further information identified to contradict data report.
Compressible Ground	Moderate	See Section 2.9.4
Collapsible Ground	Very Low	See Section 2.9.5
Running Sand	Moderate	No further information identified to contradict data report.
Volumetrically Unstable Slag	Not reported.	See Section 2.9.6
Sulphate/Pyritic Ground	Not reported.	See Section 2.9.7
Unexploded Ordnance	Not reported.	See Section 2.9.8
Notes to Table: 1. Potential as reported in environmental data report (Appendix C) 2. Salient hazards discussed in following sections.		

2.9.2 Shrinkable and Swelling Soils

From our experience, the clayey weathered bedrock soils anticipated at shallow depth beneath the site commonly have high plasticity indices and, hence, could be classified as of potential moderate volume change potential with changes in moisture content (shrinkage and swelling). Therefore, we consider that the potential for shrinkable/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 Landslides

Reference to the National Landslide Database on the website of the British Geological Survey (BGS, 2022) indicates there are no current or historic landslides present in the area surrounding the site.

Therefore, we consider that the potential for landslides at the site is consistent with the findings reported in the environmental data report (Table 3,) **Low**.

It should be noted that significant level changes are noted across the site and whilst manor landslide instability is unlikely, changes to on site topography may lead to localised instability.

2.9.4 Compressible Ground

Made Ground that is likely to be present on site, can be compressible dependant on its make up and therefore, we consider that the potential for compressible ground at the site as reported in the environmental data report (Moderate) is likely to be accurate.

2.9.5 Collapsible Ground

Some soils (both natural and man-made) can collapse (i.e. suffer a rapid reduction in volume) when loaded or saturated, which can then lead to significant damage to structures and utilities.

Based on the geological setting of the site, we consider that the risk from collapse of natural soils is low. However, man-made soils (Made Ground) are anticipated on the site which could suffer future collapse.

Therefore, we consider that the potential for collapsible ground at the site should be advanced from that reported in the environmental data report (Table 3: Preliminary Geotechnical and Geo-environmental Risk Register, Very Low) to **Moderate**.

2.9.6 Volumetrically Unstable Slag Materials

The potential for volumetrically unstable slag material to be present on the site is not considered in the environmental data report. Slag was a waste product from iron and steel manufacture, and varies chemically depending on the manufacturing process involved. There are three main types of slag, blast furnace slag, basic steel slag and acid steel slag, along with further associated refractory products. Some forms of slags, such as fresh blast furnace slag and acid steel slag, are generally volumetrically stable but, depending on their chemistry, some such as basic steel slags and weathered blast furnace slags can be extremely unstable when hydrated, which can lead to significant heave at the surface and damage to buildings and hard surfaces.

In our experience, on former industrial site such as this, there is the potential for slag materials to be present within the Made Ground. Fragment of suspected slag materials were visually observed in the site surface soils during the site visit. Given the currently available information, we cannot discount that the slag present on site could be volumetrically unstable and we consider that the risk from such instability should be considered **Moderate** at this desk study stage.

2.9.7 Pyritic Ground

The environmental data report does not consider the potential risk from sulphate rich or pyritic ground.

The weathered soils 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 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**.

2.9.8 Unexploded Ordnance

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

The site is located in a historical industrial area which is likely to have been targeted by the Luftwaffe during World War Two. Reference to the Regional UXO risk maps available on-line (Zetica, 2022) suggests that the site is located within a **Low** risk region with regards to the risk from buried unexploded ordnance. However, it should be appreciated that although the area of the site is indicated as generally of low risk, an increased could be applicable due to site-specific features, e.g. war-time activities.

Given the above, a Preliminary (Pre-Desk Study) 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 D (Zetica, 2022). This assessment indicates:

- No identified World War One military activity or bombing on site.
- No World War Two military activity on site.
- Strategic targets in the vicinity of the site to include Newport Docks, transport infrastructure, public utilities, industries important to the war effort such as collieries, Allied anti-aircraft defences.
- During World War Two the site was located in the industrial district of Newport, which had a bombing density of 12.8 bombs per 405ha. No records of bombing on the site itself have been identified.

The assessment concludes that *'a detailed desk study, whilst always prudent, is not considered essential in this instance'*.

2.10 Radon Hazard

Radon is a colourless, odourless, radioactive gas, which can pose a risk to human health. It originates in the bedrock beneath the site, where uranium and radium rich minerals are naturally present, and can move through fractures in the bedrock, and overlying superficial deposits, to collect in spaces within/beneath structures.

The environmental data report (Appendix C) indicates that the site lies in a radon affected area as defined by the Health Protection Agency, with between 1 and 3% of properties above the action level.

Reference to the UK radon maps published by Public Health England (PHE, 2015) indicates that the site lies in an area classified as a maximum radon potential of between 3 and 5%.

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 the published BRE guidance in BRE 211 (Scivyer, 2007) indicates that the site lies in a 1km square where the maximum requirements are for basic radon protection measures in new buildings (domestic or non-domestic). Given the currently available information, the risk from radon is considered **Moderate** and should be confirmed with the local Building Control Department.

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 (both contamination and hazardous gas), the receptors at risk (both human and non-human), and any feasible pathways between the two. These are discussed in the following sections.

3.1.2 Potential Soil Contamination Sources

The site has previously been developed with a works that has evolved into the current manufacturing and storage facility on site. In addition to this, a number of potentially contaminative historical land uses are recorded in close proximity such as a gas works, nail factory and allotment gardens.

3.1.3 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);
- 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 is discussed in Section 2.10

3.1.4 Potential Sources of Hazardous Ground Gas

This section considers the potential sources of hazardous gases such as methane, carbon dioxide and hydrocarbon vapours. The potential for radon was discussed in Section 2.10.

The site is not located within 250m of an existing or former recorded landfill, nor are there any formally recorded instances of land filling in the vicinity, however, historical mapping suggests partial infilling of the former Monmouthshire Canal to the east may have occurred.

Based on the available information, the following potential sources of hazardous ground gas have been identified on, or in close vicinity of, the site:

- General Made Ground – on site source.
- Historic Land Uses such as potential infilling of the canal, gas works and allotment gardens (off-site sources).

Based on the guidelines presented by O’Riordan and Milloy (1995) and revised by Wilson et al (2009), the above potential gas sources would generally be classified as of low gas generation potential,

3.1.5 Potential Receptors

As discussed in Section 1.1, the proposed site development will comprise a residential development with associated areas of gardens and landscaping.

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 occupiers and site visitors, the critical receptors being young children playing in gardens and landscaped areas.
- Construction and maintenance workers.
- Buried concrete (foundations, drainage etc.).
- The groundwater within the underlying bedrock strata beneath the site.
- No surface water features are indicated, with the River Usk, some 250m east.

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.

Site Users:

- Ingestion of soils and inhalation of dust in landscaping areas.
- Dermal contact with contaminated soils.
- Exposure to asbestos containing materials within the shallow soils.
- Potential exposure to flammable or toxic ground gas/vapours.
- Chronic (long term) exposure to unacceptable levels of radon.

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.

Groundwater:

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

Buildings:

- Sulphate attack on buried concrete (foundations, drainage etc.).

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 general 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 by ESP 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 4 in Section 3.2.2 below.

3.2.2 Tabulated Preliminary Risk Evaluation & Plausible Pollutant Linkages

Table 4: 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 from previous land uses (allotment gardens) and adjacent land uses such as works and gas works.	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users	Medium – potential for chronic levels.	Likely ²	Moderate 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	Low Risk	
	Leaching of soil contaminants	Impact on Groundwater /Potable Water	Medium – site lies on Secondary Aquifer	Low likelihood ²	Moderate/Low Risk	Sampling of near-surface soils to confirm levels of leachable contamination present.
	Leaching of soil contaminants	Impact on surface waters	Medium	Low likelihood ²	Moderate/Low Risk	
Asbestos in shallow soils	Ingestion of fibres	Construction/ Maintenance Workers	Medium – potential for chronic levels	Moderate Likelihood ³	Moderate Risk	Sampling of shallow soils for asbestos.
Soil sulphate and pyrite	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Moderate likelihood ⁴	Moderate Risk	Sampling of soils to confirm levels of sulphate, pH, and groundwater.
Hazardous ground gas/vapours from on site and off site sources	Asphyxiation/poisoning. Injury due to explosion.	Site Users	Severe – acute risk.	Likely	Moderate/High Risk	Establish ground model and if necessary, install and monitor gas wells.
	Damage through explosion.	Building/Property	Severe – acute risk.		Moderate/High Risk	
	Asphyxiation/poisoning. Injury due to explosion.	Construction and Maintenance Workers.	Severe – acute risk.		Moderate/High Risk	
Radon gas	Migration into Buildings	Site Users	Medium – potential for chronic levels	Likely ⁵	Moderate Risk	See Section 2.10.

Notes to Table:

1. Methodology and details of risk consequence, probability and category based on CIRIA C552 (2001) and presented in Section 3.2.1.
2. The presence of Made Ground or contamination has not yet been confirmed on site.
3. No obvious asbestos materials have been observed in the Made Ground soils, existing buildings may contain asbestos.
4. Potential for elevated levels of sulphate and acidic soil conditions to be present.
5. Radon risk identified in environmental data report.

4 Exploratory Investigation

4.1 Investigation Points

4.1.1 Introduction

The intrusive investigation was undertaken between 29th and 30th June 2022 in accordance with BS5930:2015 and BS10175:2017, and was designed to investigate both geo-environmental and geotechnical hazards identified in the desk study (Section 2). It comprised trial pitting, windowless sample boreholes and soakaway infiltration testing.

The exploratory holes were supervised and logged by an engineering geologist in general accordance with BS5930:2015, BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2018, and BS EN ISO 14689:2018, along with published weathering schemes. The investigation point positions are shown on Figure 1.

The ground levels indicated on the investigation point records are approximate only and have been interpolated from ordnance datum. The coordinates shown on the investigation point records are approximate only and have been interpolated from the topographical survey/recent Ordnance Survey maps.

4.1.2 Investigation Strategy

The investigation strategy was generally designed in accordance with BS10175:2017, taking into account the additional potential for geotechnical hazards to be 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 existing buildings, substantial concrete slabs, services and boundaries between level changes across the site.

Notwithstanding the above constraints, we consider that the investigation undertaken has been sufficient to identify the key ground conditions at the site.

4.1.3 Trial Pits

2no. trial pits (TP01 to TP02) were excavated across the site on 29th June 2022 using a wheeled, back acting hydraulic excavator. The trial pits were excavated to depths of between 2.0 and 2.1m. The tarmac surface was broken out prior to the excavation of the pits using a hydraulic breaker. The trial pit records are presented as Appendix F, and their positions are shown on Figure 1.

Disturbed samples were collected from the trial pits for laboratory testing as shown on the trial pit records.

On completion, the trial pits were backfilled with arisings in layers compacted with the excavator bucket. The tarmac surface was not reinstated. The arisings were left slightly proud of the adjacent surface to allow for future settlement.

4.1.4 Windowless Sampling

4no. windowless sample drillholes (WS01 to WS04) were constructed on the 30th June 2022 to depths between 2.7m and 5.0m. The borehole records are presented as Appendix E, and their positions are shown on Figure 1.

A hydraulically powered rig was used to drive plastic lined sampling tubes into the ground, with the soil recovered within the tubes, which are then split to allow sampling and logging. Disturbed samples were

obtained throughout the boreholes for identification and laboratory testing purposes, as shown on the borehole records. The windowless sampling provided generally good recovery to the depth of refusal.

At the commencement of the boreholes the surface tarmac/concrete was broken out using a hydraulic breaker and a service inspection pit excavated by hand to a depth of 1.2m.

Standard Penetration Tests (SPT) were carried out using a split spoon in the boreholes in accordance with BS EN ISO 22476-3 (2005) and BS5930 (2015) to assess the relative density of the coarse-grained soils encountered in the borehole and to provide a correlated assessment of the likely undrained shear strength of fine-grained soils using relationships published by Stroud (1975). As required in BS5930:2015, the SPT N-values shown on the borehole records are the direct, uncorrected results obtained in the field.

Depending on the nature of the test undertaken and the soils subjected to testing, field SPT N-values may require correction before using in design. In accordance with BS EN ISO 22476-3 (2005), SPT N-values in sandy soils need to be corrected for a number of aspects such as overburden pressure, rod length and rod energy ratio in sands.

4.1.5 Soakaway Infiltration Testing

Soakaway infiltration tests were undertaken in two selected trial pits across the site (TP01 and TP02). The results of the infiltration testing, and the calculated infiltration rates, are presented in Appendix I. The positions of the test pits are shown in Figure 1.

At each position, the test pit was excavated to a depth of 2.0 and 2.1m which was anticipated to be a possible depth for the soakaway given the ground conditions identified and taking into account any proposed change in ground levels. Clean water was added from a large capacity bowser and the water level monitored as it percolated into the soil.

An infiltration rate is calculated from the time taken for the water to fall between the 75% and 25% full level. Where insufficient time was available for the water level to fall to the 25% full level, but a significant drop in water level was recorded, the infiltration rate can sometimes be estimated by extrapolating the test results. However, where the water level only dropped marginally during the available test period (e.g. not as far as the 75% full level), we consider that there is insufficient data to allow a valid extrapolation with any confidence and no infiltration rate can be estimated.

With regard to this site, insufficient infiltration was recorded over two consecutive days to allow either determination of a rate nor extrapolation.

Herras fencing was erected around the test pits during the testing to protect site workers and the general public. 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.

4.2 Instrumentation

4.2.1 Gas Well Installations

Due to the presence of Made Ground, historical land uses and adjacent potentially gas-producing previous land uses, a 50mm diameter monitoring well was installed in selected boreholes in accordance with BS8576:2013 in order to allow monitoring of hazardous ground gases. The wells, comprising slotted plastic pipe with a gravel surround (the response zone), bentonite seals above the response zone, and

a lockable vandal proof cover, were installed as detailed on the borehole records and summarised in the Table 5 below.

Table 5: Gas Well Installations

Well ID	Date of Installation	Response Zone depth	Response Zone Stratum	Rationale
WS01	30/06/2022	0.5 – 2.0m	Made Ground	2
WS02	30/06/2022	0.5 – 2.0m	Made Ground	2
WS03	30/06/2022	0.5 – 2.0m	Made Ground	2
Notes: 1. Details of each monitoring well are presented on the individual borehole records (Appendix E). 2. Well installed in Made Ground and weathered St Maughans Group.				

Monitoring has been undertaken on 6no. occasions between 9th August 2022 and 28th October 2022. During each visit, Gas Data LMSxi G3.18e portable monitoring equipment was used to measure levels of the following ground gases within the airspace in the wells and the flow rates from the wells:

- Methane - total and percentage of Lower Explosive limit (LEL);
- Carbon dioxide;
- Oxygen; and
- Hydrogen sulphide.

The percentage of nitrogen is also calculated by difference. The equipment uses infra-red methane (CH₄) and carbon dioxide (CO₂) detectors, coupled with pressure (barometric and well), temperature and flow sensors.

Following measurement of gas levels and flow rates, the well cap was removed, and groundwater levels were measured using a dipmeter from the site surface.

4.3 Sampling Strategy

4.3.1 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 4.4 and 4.5). A non-targeted, random sampling strategy was used to obtain representative information on soil contamination across the site as a whole. However, a number of constraints were imposed on the available sampling locations by existing buildings and services etc. and therefore a regular grid sampling pattern could not be adopted.

Environmental samples (denoted as ES on the exploratory holes records) were collected for possible geo-environmental laboratory testing and generally comprised a plastic tub, an amber glass jar and an amber glass vial. The sample containers provided clean by the testing laboratory appropriate for the proposed testing to be scheduled. Immediately after collection the samples were placed in sealed cool boxes with ice packs where they remained during storage and transport to the laboratory. Samples for logging and geotechnical laboratory testing purposes were collected at regular intervals within the exploratory holes.

4.3.2 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). Cutting relatively undisturbed block samples from trial pit walls provides Class 1 or 2 samples, provided that they are collected, preserved and transported in an appropriate manner.

The split spoon sample from a Standard Penetration Test (SPT) is usually considered a Class 5 sample however, it can be deemed Class 4 in homogeneous fine-grained soils. Disturbed sampling (bulk bags and small tubs) from boreholes is considered Class 3 (if dry), Class 4 (fine soil below the water table) or Class 5 (coarse soils from beneath the water table).

The samples recovered within the liner in windowless sampling are generally Class 3 in fine-grained soils with good recovery, becoming Class 2 in favourable circumstances, but Class 3 or 4 in coarse-grained soils. The quality class of each sample collected as part of the investigation is shown on the exploratory hole records.

4.4 Evidence of Site Hazards Found During Site Works

4.4.1 Site Stability

No evidence of geotechnical hazards was identified in the exploratory holes.

4.4.2 Site Evidence of Contamination

Made Ground was encountered across the site, however, no direct visual/olfactory evidence of contamination was identified in the exploratory holes. However, Made Ground can contain elevated levels of contaminants such as metals and polyaromatic hydrocarbon (PAH) compounds.

4.5 Geotechnical Laboratory Testing

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

The following tests 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 I.

- Natural moisture content.
- Atterberg limits.
- Particle size analysis.

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 2.9.7), 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). The results of the sulphate testing are included with the geo-environmental test results in Appendix H.

4.6 Geo-environmental Laboratory Testing

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

The Preliminary Risk Assessment (Section 3) did not identify any particular contaminants of concern at the site. However, given the identified presence of Made Ground in the exploratory holes, in order to allow an assessment of the potential chronic risks posed to human health, a total of 5 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:

- heavy metals and semi-metals (arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- cyanide, sulphate, sulphide;
- polyaromatic hydrocarbon (PAH) compounds;
- phenols;
- asbestos.

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

5 Development of the Revised Conceptual Model

5.1 Conceptual Ground Model - Geology

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

Made Ground (North Portion): encountered in WS01 to a maximum depth of 2.1m as a clayey gravel, occasionally a gravelly clay with frequent man made fragments such as brick, concrete, limestone gravel, rare coal and rare slag.

Made Ground (South Portion): encountered in TP01 – TP02 and WS02 – WS04, to depths of between 0.4m and 1.2m as a concrete slab (within the existing building) followed by a sub-base horizon and reworked St Maughan's group bedrock. WS02 differed, comprising a reworked horizon of bedrock with man made fragments.

St Maughan's Group Bedrock: encountered below the Made Ground in all exploratory positions and proven to a maximum depth of 5.0m and whilst some variation was noted, was generally recovered as a gravelly, silty, clay.

Particle size analyses within the laboratory have indicated the recovered weathered bedrock to comprise 0-28% cobbles, 4-7% gravel, ~13% sand and 55-80% clays and silt. Based on our observations on site, these proportions would appear representative of the recovered weathered bedrock. It should be noted that as this material comprised weathered rock, recovered by mechanical means, the particle size distribution should not be considered representative of all weathered bedrock.

Geotechnical laboratory test results have indicated that the fine fraction of soils tested, identify moisture contents between 11-13%, liquid limits between 27-42%, plastic limits between 15-17% and plasticity indices of between 12-25%.

The limited soils tested, classify generally as of intermediate plasticity and medium/high shrink swell potential.

5.2 Conceptual Ground Model - Hydrogeology

During the investigation, no groundwater was encountered, however, anticipated perched water was encountered in one location (TP02) with a minor inflow noted within the Made Ground at a depth of 0.5m.

5.2.1 Hydraulic Gradient

Monitoring of groundwater levels has been undertaken as part of ground gas monitoring (see Section 5.6) and indicates the potential for groundwater <2.0m depth.

5.3 Site Instability

No obvious evidence for instability was noted during the investigation.

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 2013, CL:AIRE published the Category 4 Screening Levels (C4SL – CL:AIRE, 2013) 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. 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). The C4SL have also only been published for a limited number of contaminants commonly identified in contaminated land risk assessments at present (arsenic, cadmium, chromium VI, lead, benzene, benzo[a]pyrene). However, the C4SL have been published for a range of land uses, including residential, commercial, allotments and two types of public open space.

The C4SL 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). The Welsh Local Government Association and Natural Resources Wales (WLGA/NRW) have confirmed that, *'where the site conditions are applicable to the land use scenarios adopted in their calculation, the C4SL levels can be used as screening tools'* for development site risk assessments (WLGA/NRW, 2017). The C4SL have also been accepted by the NHBC for use as generic screening levels on residential developments in England and Wales (NHBC, 2014). Given this, where available and applicable, the C4SL have been adopted as the Generic Assessment Criteria in this assessment.

Where no C4SL is currently available, the Suitable For Use Levels (S4ULs) published in January 2015 by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM) (Nathanail et al, 2015) have been adopted. These assessment criteria adopt updated toxicological data and exposure models, and 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.

Where no C4SL or S4UL is available, the Soil Guideline Values (SGV) published by the Environment Agency have been adopted as the Generic Assessment Criteria (GAC) – note several SGV have been withdrawn since originally published. However, the SGV are only available for a limited number of contaminants for three proposed land uses (residential, commercial and allotments – and not public open space).

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).

Details of the Generic Assessment Criteria (GAC) adopted for each contaminant are presented on the assessment tables in the following section.

The proposed development comprises conventional residential properties with private gardens and landscaping. Therefore, the GAC appropriate for the residential land use with plant uptake have been adopted in this assessment.

The GAC for most organic compounds are dependent on the organic content of the soil. Analysis has shown that the soil organic content in the soils analysed ranged from 0.1% to 1.5%. Therefore, for the purposes of this assessment, GAC for a soil organic content of 1% has been adopted. This again is considered a conservative approach for the majority of the soils at the site.

5.4.3 Generic Quantitative Risk Assessment

At this stage, all samples have been considered across the site as one averaging area. If any exceedances are identified, a statistical analysis based on particular averaging areas may be undertaken to further assess the risks. The risks from asbestos are considered further in Section 5.4.4.

The results of the Generic Quantitative Risk Assessment for the proposed development are presented in Table 6. below. It should be appreciated that if the development were to change, the following assessment should be reviewed and, if necessary, updated.

Table 6: Generic Assessment of Human Health Risks

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	1.3 – 4.1mg/kg	37mg/kg	C4SL ²	None of 7
Barium ⁶	140 - 670mg/kg	1,300mg/kg	CL:AIRE/EIC ⁵	None of 7
Beryllium	<0.2-1.4mg/kg	1.7mg/kg	S4UL ⁴	None of 7
Boron	<0.2 – 0.8mg/kg	290mg/kg	S4UL ⁴	None of 7
Cadmium	<0.1-8.3mg/kg	26mg/kg	C4SL ²	None of 7
Chromium (total) ⁷	8-37mg/kg	910mg/kg	S4UL ⁴	None of 7
Chromium (hexavalent)	<1.0mg/kg	21mg/kg	C4SL ²	None of 7
Copper	7.8-18mg/kg	2,400mg/kg	S4UL ⁴	None of 7
Lead	12-94mg/kg	200mg/kg	C4SL ²	None of 7
Mercury ⁸	<0.05-0.07mg/kg	40mg/kg	S4UL ⁴	None of 7
Nickel	7.4-43mg/kg	130mg/kg	S4UL ⁴	None of 7
Selenium	<0.5-1mg/kg	250mg/kg	S4UL ⁴	None of 7
Vanadium	12-43mg/kg	410mg/kg	S4UL ⁴	None of 7
Zinc	39-180mg/kg	3,700mg/kg	S4UL ⁴	None of 7
Polyaromatic Hydrocarbons (PAH)				
Acenaphthene	<0.03 – 1.2mg/kg	210mg/kg	S4UL ^{4,9}	None of 7
Acenaphthylene	<0.03 – 0.18mg/kg	170mg/kg	S4UL ^{4,9}	None of 7
Anthracene	<0.03 – 0.45mg/kg	2,400mg/kg	S4UL ^{4,9}	None of 7
Benzo(a)anthracene	<0.03 – 1.9mg/kg	7.2mg/kg	S4UL ^{4,9}	None of 7
Benzo(a)pyrene	<0.03 – 3.4mg/kg	5mg/kg	C4SL ^{2,9}	None of 7
Benzo(b)fluoranthene	<0.03 – 3.6mg/kg	2.6mg/kg	S4UL ^{4,9}	None of 7
Benzo(ghi)perylene	<0.03 – 1.9mg/kg	320mg/kg	S4UL ^{4,9}	None of 7
Benzo(k)fluoranthene	<0.03 – 1.6mg/kg	77mg/kg	S4UL ^{4,9}	None of 7
Chrysene	<0.03 – 2.6mg/kg	15mg/kg	S4UL ^{4,9}	None of 7
Dibenzo(a,h)anthracene	<0.03 – 0.4mg/kg (Mean = 0.08mg/kg)	0.24mg/kg	S4UL^{4,9}	1 of 7 (TP02)
Fluoranthene	<0.03 – 3.8mg/kg	280mg/kg	S4UL ^{4,9}	None of 7
Fluorene	<0.03 – 0.81mg/kg	170mg/kg	S4UL ^{4,9}	None of 7
Indeno(123-cd)pyrene	<0.03 – 1.3mg/kg	27mg/kg	S4UL ^{4,9}	None of 7
Naphthalene	<0.03 -0.07 mg/kg	2.3mg/kg	S4UL ^{4,9}	None of 7
Phenanthrene	<0.03 – 2.4mg/kg	95mg/kg	S4UL ^{4,9}	None of 7
Pyrene	<0.03 – 3.0mg/kg	620mg/kg	S4UL ^{4,9}	None of 7
Notes to Table: - Assessment for residential land use <u>with home-grown produce uptake</u> (apart from barium – see Note 6 below). - C4SL: Category 4 Screening Level, published by CL:AIRE. - SGV: Soil Guideline Value published by Environment Agency. - S4ULs Suitable 4 Use Levels. Copyright Land Quality Management Limited, reproduced with permission; Publication No. S4UL3156. All Rights Reserved. - CL:AIRE/EIC GAC published by CL:AIRE and Environment Industries Commission. - GAC for barium for residential use without plant uptake. No GAC published for plant uptake risk drivers. - In the absence of Chromium VI, all chromium present likely to be Chromium III. GAC for Chromium III adopted. - GAC for inorganic mercury adopted. - GAC for organic compounds based on 1% soil organic content. - GAC for xylene based on p-xylene (lowest S4UL). - Exceedances highlighted in red. - Laboratory results presented in Appendix H.				

The levels of Dibenzo(a,h) anthracene were found to be elevated above the adopted GAC in one sample (of 7no. tested). A sample mean of 0.08mg/kg across the whole sample population is below the guideline value.

5.4.4 Asbestos

A qualitative analysis has identified chrysotile asbestos present as bundles of fibres in two samples, both obtained from sample location WS01 (0.4m and 1.0m). Further quantitative testing has not yet been undertaken.

5.5 New Planting

Soil contamination can have a deleterious impact on the health of new plants. Such 'phytotoxic' effects can include inhibited growth, nutrient deficiencies and discolouration of vegetation. However, the potential impact on planting is difficult to quantify partly due to differing abilities of various plants to tolerate different soil conditions.

Contaminants are taken up by plants in a number of ways, the principal mechanism being via root uptake, but also including adsorption to roots. The impact on contaminants on plant growth depends on a number of factors, including the plant species, the soil type, the soil pH, the availability of the contaminant, and the impact of other external stresses on the plant such as drought.

The British Standard for the provision of Topsoil (BS3882:2007) provides guidance on acceptable levels of copper, nickel and zinc within a growing medium, which vary with soil pH value. ICRCL 70/90 (1990) discussing the restoration of metalliferous mining sites also provides 'threshold trigger levels' for a number of metals and fluoride, below which there should be no impact on plant growth. Finally, MAFF (1998) provides assessment criteria for the assessment of the impact of a number of metals on the growth of plants. For the purposes of this assessment, we have adopted the BS3882 guidance values in the first instance, followed by the MAFF published guidelines, and finally the ICRCL 'trigger values'.

The assessment along with the assessment criteria adopted are presented in Table 7 below:

Table 7: Assessment of Risks to Planting

Determinand	Range Recorded	GAC	Source of GAC	Exceedances
Metals and Semi-metals				
Arsenic	1.3 – 4.1mg/kg	250mg/kg	MAFF ¹	None
Cadmium	<0.1-8.3mg/kg	3mg/kg	ICRCL ²	2 of 7
Chromium (total) ⁶	8-37mg/kg	400mg/kg	MAFF ¹	None
Copper	7.8-18mg/kg	200mg/kg (pH>7)	BS3882 ³	None
Lead	12-94mg/kg	300mg/kg	MAFF ¹	None
Mercury	<0.05 – 0.07mg/kg	1mg/kg	MAFF ¹	None
Nickel	7.4-43mg/kg	110mg/kg (pH>7)	BS3882 ³	None
Zinc	39-180mg/kg	300mg/kg (pH>7)	BS3882 ³	None
Notes to Table: - MAFF: Ministry of Agriculture, Fisheries and Food guideline for maximum permissible concentrations in agricultural soils. - ICRCL: ICRCL 70/90. - BS3882:2007 – values dependent on soil pH values. - Laboratory test results presented in Appendix ??.				

The testing has indicated levels of cadmium to be present at concentrations which could be potentially phytotoxic to new planting. This should be considered in designing the planting regime for the development.

5.6 Hazardous Ground Gas

5.6.1 Degradation of Organic Materials

As discussed in Section 4, the installed gas wells have been monitored for hazardous gases on six occasions, i.e. the monitoring period has been completed. The monitoring results are presented in Appendix G and are summarised in Table 8 below, these values are of the maximum and minimum recorded over the period of monitoring and may not represent the steady state levels:

Table 8: Summary of Gas Monitoring Data (Visits 1 to 6)

Well	Response Zone Depth ¹ (m)	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Gas Flow (L/hr)	Water depth (m)	Atmospheric pressure
WS02	0.5 – 2.0	0.0	0.0 – 1.8	18.1 – 20.8	0.0 – 0.7	1.58 – 1.98	1000 - 1025
WS03	0.5 – 2.0	0.0	0.0 – 1.4	16.1 – 20.8	0.0	1.93 – 2.03	
WS01	0.5 – 2.0	0.0	0.0 – 0.9	17.8 – 20.6	0.0	Dry	
Notes to Table:							
1. Full monitoring results presented in Appendix G.							

The monitoring to date has indicated levels of methane were generally below the detection limit (<0.2%) . Carbon dioxide levels were between below detection limit (0.1%) and 1.8%. Oxygen was found to be marginally depleted on occasions.

Measurable gas flow rates were recorded within WS02 (up to 0.7L/Hr) however, no flow was recorded in the other two borehole installations.

Levels of volatile organic compounds were recorded as between below the limit of detection and 0.3%. Monitoring has been undertaken during atmospheric pressures of 1000 to 1025Mb and during steady and falling pressure events.

5.6.2 Gas screening values

The results of monitoring undertaken has been used to calculate Gas Screening Values (GSV) appropriate for the site using the methodology published in CIRIA C665 (Wilson et al, 2007). The calculated GSV for the site are presented in Table 9:

Table 9: Gas Screening Values (based on six visits)

	Maximum Steady State Recorded (%)	Maximum Steady State Gas Flow Rate (L/hr)	GSV (L/hr)
Methane	0.0	0.7	N/A
Carbon dioxide	1.8	0.7	0.0126
Notes to Table:			
1. GSV calculated using method derived in CIRIA 665 (2007).			
2. No flow recorded so a nominal 0.1 litres/hour has been used			

5.6.3 Radon

As discussed in Section 2.10, basic radon protection is indicated to be required for the development.

5.7 Sulphate Attack

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

5.7.1 Classification of Site

Due to the presence of Made Ground on the site, we consider that it should be considered as 'brownfield' in terms of concrete classification.

5.7.2 Groundwater Setting

Groundwater was encountered in the exploratory holes and installed wells in the shallow soils. This is likely to be close to the depth to which buried concrete will be placed. Therefore, groundwater has been considered as mobile in this assessment.

5.7.3 Sulphate Levels

Laboratory test results indicate the levels of water soluble sulphate (as SO_4) in the Made Ground soils to be between 37 and 360mg/l. Levels of acid soluble sulphate varied between 0.03 and 0.24% and total sulphur between 0.01 and 0.16%. From these results, the calculated levels of total potential sulphate are between 0.03 and 0.48%, and oxidisable sulphides are between 0% and 0.24%. As the levels of oxidisable sulphide are below 0.3%, pyrite is unlikely to be present.

pH values varied between 6.8 and 8.7, indicating near neutral to alkaline soil conditions to exist. As the pH levels all exceed 5.5, there is no need to further assess the soils for the types of acids present (e.g. hydrochloric and nitric acids).

5.7.4 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:	360mg/l;
Total potential sulphate:	0.48%;
pH value:	6.8

6 Phase Two Geo-Environmental Risk Assessment

A review of the site history has indicated that the site has previously been occupied by allotment gardens and a works with adjacent land uses noted to comprise works and a gas works

A layer of Made Ground underlies the site, however, no obvious sources of contamination were identified. Whilst laboratory testing has indicated generally low levels of potential contaminants however, elevated PAH has been identified in one location.

6.1 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 3, Section 3.2.2) have been updated and revised in Table 10 following information learned from the exploratory works and results of monitoring and laboratory testing.

Table 10: 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 from previous land uses (allotment gardens) and adjacent land uses such as works and gas works.	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Site Users	Medium – potential for chronic levels.	Likely ²	Moderate Risk	Supplementary, post demolition, investigation will be required. See Section 7.1.2 for further discussion.
	Direct contact/ inhalation/ ingestion of contaminated soil or dust	Construction/ Maintenance Workers	Minor – standard PPE likely to be sufficient	Low likelihood ²	Low Risk	
	Leaching of soil contaminants	Impact on Groundwater	Medium – site lies on Secondary Aquifer	Low likelihood ²	Low Risk	
	Leaching of soil contaminants	Impact on surface waters	Medium	Low likelihood ²	Low Risk	
Soil sulphate	Aggressive groundwater	Buried Concrete	Mild – damage to structures	Likely ³	Moderate Risk	See Section 7.3.2 for further discussion.
Asbestos	Ingestion of fibres	Demolition/ Construction Workers	Medium – potential for chronic levels	Likely ⁴	Moderate Risk	See Section 7.1.1 for further discussion.
Hazardous Ground Gas/ Vapours from on and off site sources	Asphyxiation/ poisoning, injury by explosion	Site Users	Severe	Low Likelihood ⁵	Moderate Risk	See Section 7.2 for further discussion.
	Damage through explosion	Buildings	Severe		Moderate Risk	
	Asphyxiation/ poisoning, injury by explosion	Construction/ Maintenance Workers	Severe		Moderate Risk	
Radon Gas	Migration into Buildings	Site Users	Medium – potential for chronic levels	Likely ⁶	Moderate Risk	No radon protection required.
Notes to Table: - This table updates Table 4 in Section 3.2.2 using results of the investigation. Methodology and details of risk consequence, probability and category presented in Appendix A. - Some areas of thick Made Ground have been encountered (WS01 and WS02) and some potentially significant contaminative former land uses have been encountered. - Slightly advanced class of concrete required. - Asbestos detected. - Ground gas monitoring wells have been installed and monitored. - Radon risk identified in environmental data report – see Section 2.10.						

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

A qualitative analysis has identified chrysotile asbestos present as bundles of fibres in two samples, both obtained from sample location WS01 (0.4m and 1.0m).

Further quantitative testing has not yet been undertaken and we would recommend that this quantification is undertaken on these samples.

We understand that an asbestos survey of the building has been undertaken and whilst provided to ESP, we have not reviewed in detail as we are not asbestos specialists. Any asbestos containing materials in the existing buildings will need to be removed by specialists prior to demolition.

There is no clear UK guidance on what would constitute an acceptable concentration of asbestos in soil. Therefore, we recommend that all asbestos contaminated soils be removed from site prior to development. Working with asbestos (even within soils) is governed by the Control of Asbestos Regulations (2012). This requires that the excavation and removal of the asbestos contaminated soils must be undertaken by a licensed contractor. Alternatively, an asbestos specialist may be employed to undertake further assessment of the risk from the asbestos present in the soils beneath the site with a view to investigating whether there would be an alternative risk mitigation method to prevent the expensive and non-sustainable removal and disposal of soils.

The following sections presume that any risks from asbestos materials at the site are mitigated.

7.1.2 Site End Users

The levels of Dibenzo(a,h) anthracene were found to be elevated above the adopted GAC in one sample (TP02). A sample mean of 0.08mg/kg across the whole sample population is below the guideline value. In addition to this, whilst below guideline values, other PAH compounds were also identified in this location indicating a differing soil chemistry around TP02.

Following demolition supplementary sampling will need to be undertaken to confirm ground conditions in currently inaccessible areas. This supplementary sampling should include further assessment around TP02 to determine the extent of PAH contamination in this area.

Depending on the outcome of this supplementary assessment, remedial measures may be required which may comprise the use of a separator and clean cover system. This should be confirmed during the recommended supplementary works.

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

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.

Notwithstanding the above, we recommend that construction workers adopt careful handling of the potential contaminants and good standards of personal hygiene should be adopted to reduce the risk of possible ingestion and skin contact should any hotspots be encountered. The contractor should comply with the appropriate current Health and Safety at work legislation.

The above precautions would be required for both construction workers during development and maintenance workers following development. A copy of this report and these recommendations should be included in the Health and Safety File for the development and provided to all future ground workers, including utility companies so that they may undertake their own assessment of risks to their operatives.

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 from Ground Gas

7.2.1 Risk to the Development – Degradation of Organic Material

Monitoring wells have been installed and monitored on six occasions, in order to provide an assessment of potential gas risk at the site. Monitoring has indicated no methane, carbon dioxide up to 1.8% and flow rates of less than 0.7L/Hr.

Based on these values and calculation of an appropriate Gas Screening Value (GSV), the site is classified as Characteristic Situation 1 (CS-1) for which no special ground gas protection measures are required.

Notwithstanding this, as the site is in an area that has had potentially contaminative former uses, and the site has been formerly developed (with areas of the site not yet investigated) and some low levels of ground gas have been encountered, it is considered that some pre-emptive protection would be prudent, whilst not strictly required in line with guidance. As the site requires the use of radon protection measures (see Section 7.2.2), the use of a proprietary gas resistant

membrane (resistant to radon and other ground gases) would offer the development further informal protection when installed as part of foundation and floor slab solutions.

If during the supplementary recommended investigation works, any ground conditions are encountered which may present a ground gas risk or are organic in nature, works should stop whilst the advice of a specialist is sought.

7.2.2 Risk to the Development – Radon

As discussed in Section 3.1.4, the Preliminary Risk Assessment has indicated that radon protection is required.

We would note that the British Geological Survey is currently updating their risk mapping (2022), and this should be reviewed when the new survey is available.

7.2.3 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.

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

7.3 Risks to Property

7.3.1 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.

7.3.2 Sulphate Attack on Buried Concrete

The following characteristic values are applicable for the shallow soils at the site (all as SO₄):

Water soluble sulphate:	360mg/l;
Total potential sulphate:	0.48%;
pH value:	6.8

Based on these characteristic values, we consider that the site would be classified as Design Sulphate Class DS-2 and Aggressive Chemical Environment for Concrete Class AC-2, allowing for mobile groundwater.

During supplementary, post demolition works, additional testing should be undertaken to confirm this.

7.4 Risks to New Planting

As discussed in Section 5.11, analysis of the shallow soils has indicated the levels of cadmium to be above the respective assessment criteria. Therefore, phytotoxic impact on future planting could occur. A landscaping specialist should be consulted with regards to future planting.

7.5 Re-Use of Materials/Disposal of Excess Arisings

7.5.1 General Comments on Re-use/Disposal

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 (Duckworth, 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:

- Disposed at a licensed landfill;
- Disposed at a licensed, permitted soil treatment centre; or
- 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 WM3 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 Unexploded Ordnance

A preliminary UXO report was obtained for the site that concluded that *'a detailed desk study, whilst always prudent, is not considered essential in this instance'*

8.1.2 Invasive Plants

No evidence of invasive plants such as Japanese Knotweed/Himalayan Balsam etc. was identified on the site during the site works, however, ESP are not experts and this should be confirmed by a specialist.

8.1.3 Existing Foundations and Services

The site has previously been developed and old foundations and underground structures are anticipated beneath the site. These sub-structures and any others identified during development should be grubbed up within the zone of influence of the development as part of the site preparation works.

As part of this assessment, service plans have been obtained by ESP from the utility companies – copies of this service information are presented in Appendix L at the rear of this report.

Site observations and the utility plans indicate that the site is crossed by the following services:

- Electricity cables on pylons across the southern area;
- A small substation, located on site (we understand from the client this is disconnected);
- Storm and foul sewerage in the eastern and northern portions.

All services will need to be protected and/or diverted prior to any development.

8.1.4 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.

8.1.5 Earthworks

We have not been advised that the development requires any significant earthworks, however, a level change is present between the north and south portions, and at the south boundary, that will likely require some form of retaining structure.

Any changes to topography may affect the stability of the site and as part of detailed design, should be assessed further and if necessary a formal stability assessment undertaken once the proposed design is finalised.

8.2 Geotechnical Risk Register

8.2.1 Updated Geotechnical Risk Register

Following the site investigation the potential geotechnical hazards have been re-assessed as described in the following section. This includes construction risks identified by the intrusive investigation.

8.2.2 Shrinkage and Swelling

Geotechnical laboratory test results have indicated that the fine fraction of soils tested, identify moisture contents between 11-13%, liquid limits between 27-42%, plastic limits between 15-17% and plasticity indices of between 12-25%.

The limited soils tested, classify generally as of intermediate plasticity and medium/high shrink swell potential.

8.2.3 Compressible Soils

A thick horizon of Made Ground/reworked soils has been identified in the north portion. This material may be compressible. As investigations were limited to 1no. location in the north portion, this should be addressed further during supplementary investigation.

8.3 Foundation Design and Construction

We understand that the site is being considered as a residential development and for the purposes and the comments and recommendations in this report assume that the development will involve the construction of typical conventional load-bearing brickwork construction. We have noted that geotechnical results are awaited and the below should be considered preliminary until this is undertaken.

On the basis of the available investigation information, we consider that 75kPa would be achievable at a depth of around 1.2m within the weathered St Maughans Group for mass concrete spread foundations and settlements would likely be within tolerable limits. In the north portion, foundations may need to be extended to depths of around 2.1m, subject to confirmation during supplementary investigation. In addition to this, subject to further plasticity testing, foundation depth may need to extend beyond zones of higher shrink/swell potential.

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.

If groundwater is encountered during excavation, to minimise the potential for excavation instability, we recommend that as short a time as possible is left between excavating the foundation trenches and pouring the concrete.

8.4 Floor Slab Foundations

Subject to confirmation of geotechnical laboratory testing, the use of cast in-situ ground bearing floor slabs is considered suitable for the development in the south portion. The underlying ground should be compacted for a depth of at least 300mm below slab formation level. On the basis of the materials observed, we anticipate that four passes of a vibratory roller with mass of five tonnes per metre width should achieve this. The formation should be inspected for any soft spots, which if found should be excavated and replaced with compacted, suitable, granular fill.

In the north portion and the area of WS02, ground bearing floor slabs are unlikely to be suitable due to the thickness of Made Ground encountered and floor slabs should be suspended. Alternatively, the Made Ground could be excavated and replaced (following screening) if ground bearing slabs are essential.

8.5 Retaining Wall Design

We have not been advised that the development requires any significant earthworks, however, a level change is present between the north and south portions, and at the south boundary, that will likely require some form of retaining structure. Any changes to topography may affect the stability of the site and as part of detailed design, should be assessed further and if necessary a formal stability assessment undertaken once the proposed design is finalised.

8.6 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. Based on groundwater observations from the site investigation, pumping may be required if perched water is encountered. 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, particularly if groundwater mobilises the coarse soils (running sands).

8.7 Soakaway Drainage

8.7.1 Soakaway Design

Soakaway infiltration tests were undertaken in two locations and (TP01 and TP02). The results of the testing are presented in Appendix G.

Poor infiltration was recorded and it was not possible to calculate an infiltration rate or extrapolate the data.

It is likely that the infiltration potential of the soils is being retarded by the fines content of the soils and when combined with the generally high groundwater level observed, it is unlikely soakaway drainage would be suitable for the scheme.

9 Recommendations

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

Required Further Actions:

- The limited soils tested, classify the near surface weathered bedrock to be generally of intermediate plasticity and medium/high shrink swell potential. Further plasticity testing should be undertaken as part of post demolition works.
- Quantification of 2no. positive asbestos ID tests.
- Supplementary investigation once design has been progressed and buildings demolished.
- Detailed liaison with asbestos specialist with regard to asbestos within the building and removal prior to demolition.
- Radon protection measures are required and level of protection should be reviewed and confirmed when the new BGS assessment is released.
- Pre-emptive use of enhanced radon/ground gas resistant membrane to offer some further protection to end users.

Recommended Further Actions:

- Careful watching brief during development for ground conditions significantly different to those identified so far, including a careful watch for potentially gassing and/or organic materials.
- Consideration of the requirements for remedial clean cover system, dependant on outcome of supplementary investigation.
- Watching brief for construction and maintenance workers should any areas of unexpected contamination be identified, associated with the contaminative former history of the site.
- Verification testing of any soils imported to site.
- WM3 assessment of soils to be disposed of off-site.
- Materials management plan for re-use of soils on site and WM3 assessment of soils to be disposed of/re-used off-site, followed by WAC testing if disposal to landfill.

10 References

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