BRISLINGTON MEADOWS BRISLINGTON MEADOWS BRISLINGTON MEADOWS BRISLING

Land Quality Statement

Homes England

CampbellReith
consulting engineers

Brislington Meadows, Brislington, Bristol

Land Quality Statement

For:

Homes England

Project Number: 13492

March 2022

Campbell Reith Hill LLP
Unit 5.03
HERE
470 Bath Road
Bristol
BS4 3AP

T: +44 (0)117 916 1066
E: bristol@campbellreith.com
W: www.campbellreith.com

Document History and Status

Revision	Date	Purpose/Status	Authors	Check	Review
P01	February 2022	For client comment	B. Reilly P. Wright	T. Tucker P. Wright	T. Tucker
P02	March 2022	Updated to include client comments	B. Reilly P. Wright	T. Tucker P. Wright	T. Tucker

Document Details

Last saved	22/03/2022 10:00
Report Version	P02
File Name	13492-CRH-XX-XX-RP-LQ-0001_P02-LQS.docx
Authors	Brandon Reilly, Phil Wright
Project Partner	Mike Lawson
Project Number	13492
Project Name	Brislington Meadows, Bristol

Contents

SUMMARY OF ACTIONS

HUMAN HEALTH	No remedial action required.
CONTROLLED WATERS	No remedial action required.
BUILDINGS AND STRUCTURES/ SERVICES	With regards to hazardous ground gas generation, the site is considered to be a CIRIA Characteristic Situation 1 and as such, gas and vapour protection measures are not considered to be necessary. The rare presence of TPH and PAH concentrations in soil indicate a potential need for protection of public water supply network. The infrastructure designer should assess the requirements for pipework with respect to soil contamination and consult statutory utility companies and relevant guidance as necessary.
SITE WORK CONTROLS	As standard, a watching brief should be maintained throughout intrusive groundworks by the Contractor such that any previously unidentified contamination or asbestos containing materials (ACM) can be identified and referred to an experienced Environmental Consultant for evaluation. Groundworks should be undertaken by a suitably qualified Contractor in accordance with the Control of Asbestos Regulations 2012, associated Approved Code of Practice (ACoP) and guidance prepared by CL:AIRE and the Joint Industry Working Group (JIWG), and CIRIA.
REGULATORY APPROVAL	This report should be submitted to the Regulators (Contaminated Land Officer / Environment Agency) for comment via the planning application process, in order to satisfy the requirements of the application and discharge conditions relating to desk study and ground investigation. A method statement for contamination (Groundworks / Remediation Specification) and verification reporting may require agreement via the planning process. A piling risk assessment may also be required.
WASTE	This LQS does not address the classification of waste soils. The soil results can however be utilised as a basis for such assessments, although additional testing may be required. It is noted that such assessments are required to accord with the Environmental Permitting and Planning Legislation and also to control costs during development.
GEOTECHNICAL ACTIONS	During construction it is recommended that once the top soil within the southern area is stripped the site should be inspected by a suitably qualified engineer do determine the presence or otherwise of historical mining works. Specialist design of any retaining walls is required by a suitably qualified engineer. The design and parameters used should be detailed in accordance with Eurocode 7.
OTHER	An intrusive UXO investigation was completed in November 2021 in line with the recommendations made in the Detailed UXO Risk Assessment and non-intrusive UXO geophysical survey. The Intrusive investigation did not identify UXO in 145 of the 196 target locations. The remaining 51 targets located in the Paddock Area were inaccessible at the time of the investigation. Additional intrusive target investigations may be required for this area in due course.
DOCUMENTATION	The following are likely to be required to control the construction works and to accord with planning requirements: Geotechnical Design Report, Groundworks Specification, Remediation Specification, Verification Report and Health and safety documentation.

EXECUTIVE SUMMARY

SITE LOCATION	The site is located in Brislington in the south east of Bristol within the administrative boundary of Bristol City Council and the Ward of Brislington East. The site is centred on National Grid Reference 326615E, 171114N and postcode BS4 4NZ approximately 4km from Bristol City centre.
ENVIRONMENTAL SETTING	The site is underlain by bedrock geology of the Farrington and Barren Red Formation. Superficial Head deposits were encountered in limited areas of the site. The overall environmental sensitivity of the site is considered to be Moderate – High based on the following classifications: Hydrology [High]: Surface water ditch adjacent to the southern boundary of the site is considered to provide contributory flow to the nearby Brislington Brook and River Avon. Hydrogeology [Moderate]: The site is underlain by a Secondary A aquifer associated with the Farrington and Barren Red Formation.
CURRENT USE AND PROPOSED DEVELOPMENT	The site comprises an irregular shaped parcel of land (9.6 hectares) comprising predominantly greenfield. An electricity pylon and overhead electricity cables are present in the south of the site and a telecoms mast is present in the west of the site. The proposed development comprises up to 260 residential homes with private gardens.
SITE HISTORY	Historical mapping indicates the site has predominantly comprised undeveloped grazing land. Allotment gardens were present in the west of the site from between circa. 1947 and 1965. An office building (police station) was present in the north east of the site from circa. 1999 but since demolished in October 2020.
CONTAMINATION ISSUES	Based on the results of the recently completed intrusive site investigation the following risks have been identified in relation to potential Receptors: Risk Summary: • End Users: A VERY LOW has been identified due to absence of significant contamination (soil/water/gas) encountered and no gas protection measures are considered to be required. • Groundwater: A VERY LOW risk has been identified due to the absence of significant contamination encountered. • Surface Water: A VERY LOW risk has been identified due to the absence of significant contamination encountered. • Buildings: The site has been classified as a CIRIA Characteristic Situation 1 (VERY LOW risk) and gas protection measures are not required. • Services: The presence of hydrocarbon concentrations in soil indicates a possible need for protection of public water supply pipework, such as the use of organic resistant pipework. • Groundworkers: A VERY LOW risk has been identified based on the assumption that basic health and safety provisions will be utilised.
GEOTECHNICAL RECOMMENDATIONS	Historical mining During construction and following the removal of topsoil the ground should be inspected for evidence of historical mine workings. Should evidence of bell pits or shallow mine workings be encountered a detailed programme of open-hole drilling and grouting may be required. Foundations It is considered for low rise buildings traditional strip or trench fill foundations within the weathered bedrock will suffice. Where compressible materials are present these will require excavation and replacement with lean mix concrete as the blinding concrete under foundations and as levelling course below footings. The potential for heave, desiccation and shrink-swell should be considered in accordance with NHBC standards. Piles Piling will be required in the eastern area of the site to found proposed four-storey apartments.

	Floor slabs Suspended floor slabs are required if proposed levels require more than 600mm of fill material. Heave protection measures will be required and void formers will be required below all ground beams, slabs and pile caps where piled foundations are required. Road pavements Assuming formation soils comprise a variety of cohesive and granular materials an equilibrium CBR value of 1% is recommended. Confirmatory testing of the excavation should be undertaken to confirm an accurate CBR value for the soils. Where pavement is located on fill this value may be increased subsequent to additional testing. Buried Concrete The results of the concrete classification tests have indicated a DS-1 classification, together with the pH values indicates that an ACEC AC-1 should be adopted. Drainage The soakaway test results indicate that the site is not suitable for soakaway drainage. Any drainage should be designed in accordance with NHBC to protect against the potential for ground movement Excavations Dewatering and shoring will be required for all excavations owing to the shallow nature of the groundwater. Excavated cohesive materials may be re-used for landscaping purposes. Excavated bedrock may be processed for re-use on site subsequent to suitable testing and classification in accordance with the UK Specification for Highways Works (SHW). Retaining Walls Currently the proposed development requires a degree of cut and fill that will require the provision of retaining walls to achieve the required profile, which follows the existing topography. Any retaining structures will require design by a specialist engineer. The proximity to building to the retaining wall will require careful consideration. Any requirements for retaining walls would need to be assessed upon confirmation of a final development profile.
ENVIRONMENTAL RECOMMENDATIONS	No targeted remediation works to mitigate contamination issues are considered necessary. A watching brief should be maintained throughout future phases of intrusive ground works such that any unforeseen sources of gross contamination or materials of potential concern may be readily identified and assessed if encountered. The watching brief, including photos of exposed ground, potable pipework specification (if required) and test results of imported materials should be recorded in a verification report.

1.0 INTRODUCTION

1.1. Appointment and Scope

1.1.1. This report has been produced by Campbell Reith Hill LLP (CampbellReith) on behalf of Homes England (the Client) to summarise environmental and geotechnical information relating to Brislington Meadows, Brislington, Bristol (hereafter referred to as 'the site'). The references and limitations associated with this report follow the main text. Figures showing the location of the site and the development proposals are presented in Appendix A.

1.1.2. The report has been produced in general accordance with the procedures for ground investigation, interpretation and reporting set out in Environment Agency Land Contamination Risk Management (LCRM) guidance, BS 5930:2015, BS 10175:2011 (+A2:2017) and BS EN 1997 (Eurocode 7).

1.1.3. The objective of the report is to collate and interpret Phase 1 Desk Study information and Phase 2 exploratory data in order to provide:

a) A conceptual site model for the site ground conditions (soil, water and gas);

b) A generic quantitative risk assessment (human health and controlled waters);

c) Outline recommendations for land contamination issues;

d) A geotechnical evaluation; and,

e) Geotechnical design recommendations.

1.1.4. The contamination appraisal is intended to identify remedial requirements necessary to permit the redevelopment of the site for up to 260 residential properties with private gardens.

1.1.5. This assessment considers the objectives of the National Planning Policy Framework (NPPF) which requires information to demonstrate that a site is suitable for its new use (taking account of ground conditions and land instability) and not be capable of being determined as contaminated land as defined under Part IIA of the Environmental Protection Act 1990 (after remediation). The NPPF requires adequate site investigation information, prepared by a competent person, with the minimum requirement comprising a desk study and site reconnaissance.

1.1.6. The geotechnical appraisal has been carried out in accordance with Eurocode 7. Sections 3.0 to 7.0, 11.0 and 12.0, together with Appendix C, comprise the Ground Investigation Report. Preliminary geotechnical recommendations are presented in Section 14.0 and these should be verified in a Geotechnical Design Report (GDR) once structural details of the proposed development are confirmed.

1.1.7. It should be recognised that further appraisals, investigations, specification and validation may be required to accord with the recommendations stated herein. It is noted that these appraisals do not consider wider development issues, with cost implications, such as waste classification.

1.1.8. The report is based on a recent site investigation commissioned for this project and a review of readily available information as referenced. The factual site investigation report produced by Geotechnical Engineering Limited (GEL) in February 2021, is contained in Appendix B. Information pertaining to the additional ground investigation carried out by CC Ground Investigation Ltd in 2022 is contained in Appendix C. The Non-Intrusive UXO Survey Report dated April 2021 and the Intrusive UXO Survey Report dated November 2021 are contained in Appendix D.

1.2. Previous Investigations

1.2.1. The following reports have been reviewed and are referred to as necessary:

Table 1.1: Existing Site Specific Information

Report Details	Author	Ref
Detailed Technical Due Diligence Report for the Acquisition of Brislington Meadows, Bristol, Ref: 25704, Rev: FINAL, October 2019	WSP	[1]
School Road, Brislington, Phase 1 Ground Condition Report (Project Ref. 21122, Doc Ref. DTS/Rev0 August 2011)	Peter Brett Associates LLP	[8]
Preliminary Geo-Environmental Risk Assessment, Brislington Meadows, Bristol (Ref no. 70063012-GC-PRA September 2019)	WSP	[9]
Brislington Meadows Ecological Impact Assessment (Doc ref. 7507.20.066)	TEP	[10]
Brislington Meadows, Brislington, Bristol, Historic Environment Desk-Based Assessment (Doc ref. 7507.022.002 September 2020)	TEP	[11]

2.0 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

2.1. Site Location

2.1.1. The site location is presented in Figure 1. The site is located in Brislington in the south east of Bristol within the administrative boundary of Bristol City Council and the Ward of Brislington East. The site is centred on National Grid Reference 326615E, 171114N and post code BS4 4NZ approximately 3.4km outside Bristol City centre.

2.2. Site Layout

2.2.1. The site comprises an irregular shaped parcel of Land, 9.6ha in size, known as Brislington Meadows. The site currently comprises open fields crossed by two public rights of way and a network of informal trodden paths. The site is not subject to specific environmental or landscape designations and has an allocation for housing development in the Council's Local Plan.

2.2.2. The site is characterised by a steeply sloping topography from the northern boundary down to the southern boundary, with the gradient reducing towards the east. There are overhead electricity cables and a pylon on the lower slopes towards the southern boundary of the site. A telecommunications mast towards the north east of the site will be relocated following the grant of planning consent for the proposed development.

2.2.3. The site is well located to make use of existing services and facilities. Broomhill Infant School, Broomhill Junior School and Mama Bear's Day Nursery are all located adjacent to the sites northern boundary. Broomhill local centre, including a small convenience store, public house, salons and takeaway shops, is located approximately 200m north of the site.

2.2.4. There is no public vehicular access into the site at present. There are two public rights of way across the site, one running east-west along the southern boundary connecting Bonville Road and School Road, and one north-south between Belroyal Avenue and Bonville Road. In addition, a network of informal trodden paths crosses the site. The applicant is in the process of formalising public access rights and the proposed development will accommodate pedestrian and cycle access across and within the site.

2.2.5. The site has a direct informal connection Victory Park to the south. Eastwood Farm Local Nature Reserve is located approximately 150m north of the site on the northern side of Broomhill Road. Nightingale Valley Park is located approximately 600m west of the site off Allison Road.

2.3. Invasive Plant Species

2.3.1. It is known that Japanese Knotweed has resided along the eastern boundary of the site with Bonville Road and adjacent to the copse of TPO woodland in the northeast, however, it is understood that this invasive plant species has recently been subject to ongoing treatment. Given the site has been subject to recent ecological surveys Japanese Knotweed has not been assessed further as part of this contamination assessment.

2.4. Surrounding Land Use

2.4.1. To the north east, the site is bound by Broomhill Road and residential properties in Condover Road. To the north the site is bound by residential dwellings on Belroyal Avenue and an associated rear access lane, Broomhill Junior School and Mama Bear's Day Nursery, and residences accessed off

Allison Road. To the east the site is bound by Bonville Road and the protected employment area comprising the Bonville Trading Estate. To the west of the site is School Road and allotments. To the south lie Victory Park and paddocks which comprise protected open space and a site of Nature Conservation.

2.5. Redevelopment Proposal

2.5.1. The proposed site redevelopment is shown in Figure 3.

2.5.2. The proposed development comprises the development of up to 260 dwellings with pedestrian, cycle and vehicular access, cycle and car parking, public open space and associated and associated infrastructure. All matters except access are reserved.

2.6. Geology

2.6.1. The site geology and potential geotechnical hazards is summarised below. The associated references are listed at the rear of the report.

Head

2.6.2. The published information [2] indicates that head deposits are present at the north-eastern boundary of the site comprising "poorly stratified clay, silt, sands and gravel'. The geological memoir [3] indicates that many of the head deposits within the area are "little more than a veneer of weathered material" while some can be up to 20ft in thickness. The area of Brislington is noted to comprise "*considerable expanses of red or reddish brown sandy loam*" which resembles weathered red sandy mudstone.

Farrington and Barren Red Formation

2.6.3. The site is underlain by the Farrington and Barren Red Formations of the Upper Coal Measures comprising "undivided mudstone with red sandstone and coals". The Farrington Formation comprises grey mudstones and sandstones with productive coal seams and fireclays. The coal seams are generally recorded to be mostly thin but occur at a shallow depth. The geological memoir states that the shallow occurrence of the seams in the Farrington Formation enabled working of these thin seams.

2.6.4. The Barren Red Formation is defined to include "all the unproductive measures between the Farrington and Radstock Formations" and is comprised of material similar to that in the Farrington Formation of red and grey colouration. The formation comprises of seatearth and is a brownish or maroon or grey colour when fresh, weathering to a purple or brown colour.

Coal

2.6.5. The geological map indicates the outcrop of the Salridge Coal approximately 500m northeast of the site. The Salridge Seam is reported to be 0.3m in thickness and marks the base of the Farrington and Barren Red Formations. The Bromley Coals comprising of three seams with thicknesses of 0.3m to 0.6m are recorded within the Farrington and Barren Red Formations. Each of these seams have been worked [3] however these are not shown to outcrop or sub-crop within the site area.

2.6.6. A coal measure is shown to outcrop to the south of the site with a northwest to southeast orientation. An additional seam, the Rock Coal, estimated to be 0.9m thick also outcrops south of the site and is bisected by the fault to the west. Given the southward dip of the strata these seams are not expected to be present beneath the site.

2.6.7. The Barren Red Formation comprises unproductive measures between the Farrington and overlying Radstock Formation. The Farrington Formation comprises grey argillaceous strata with productive coals.

2.6.8. A Phase 1 Ground Condition Report included within Appendix D of the WSP Technical Due Diligence Report [1] details information acquired from the Bristol Coal Mining Archives Ltd (BCMA) and the Coal Authority (CA). This information is recorded to indicate "*that it is possible that coal seams have been worked at outcrop and / or from bell pits in the area of the site from probably 1560 – 1600 or earlier*".

2.6.9. A Coal Authority report acquired for the site in September 2019 [1] indicated the following:

- No past mining is recorded;
- There are no probable unrecorded shallow workings;
- No spine roadway is recorded at shallow depth;
- No mine entries are recorded within 100m of the site;
- No outcrops are recorded;
- No opencast mines are recorded within 500m of the site;
- No area of remediation are recorded within 50m of the site;
- No damage notices or claims for the site or properties within 50m of the site have been received by the Coal Authority;
- There are no records of mine gas emissions recorded within 500m of the site.

2.6.10. A coal mining report was provided by the Bristol Coal Mining Archives (BCMA), which details the following:

- Deep workings in the Rock Vein are recorded to the west of the site and are not thought to extend east of the Flowers Hill Fault (the fault that is located approximately 200m west of the site);
- Shallow workings in the Rock Vein to the south east of the site and the excavations were likely backfilled;
- There may be shallow bell pits or shafts on the down dip side of the Rock Vein outcrop;
- It is unlikely that there are unrecorded shafts or workings north of the Rock Vein as there are no seams underlying the site in this area;
- There are no known adits or shafts inside or within 100m of the site although there remains the possibility of unrecorded shafts or bell pits;
- There is no known subsidence on the site and it is unlikely that the subsurface will be affected by ground movement from deep workings;
- It must be assumed that where coal seams outcrop at the surface they will have been worked unless proven otherwise.

2.6.11. The ground investigation did not identify any coal mining related activity or geology within the site and it is considered that the seam identified on the BGS mapping falls to the west away from the site.

2.6.12. The findings of the ground investigation are detailed in Section 7.0.

Structural Geology

2.6.13. The 1:50,000 sale geological map indicates the strata beneath the site are dipping gently to the southwest. A roughly north to south trending fault is located approximately 200m west of the site with a downthrow to the west. The coal seams within the Farrington Formation are known to occur at a shallower depth and are less effected by faulting induced deformation [3]. Consequently, the mining of thin seams within this area has been undertaken more recently compared to mining of the thicker seams in the Lower and Middle Coal Measures.

2.7. Seismicity

2.7.1. The national forward to BS EN 1998-1:2004+A1:2013 'Eurocode 8: Design of Structures for Earthquake Resistance – Part 1' states there are no requirements in the UK to consider seismic loading, and the whole of the UK may be considered an area of very low seismicity in which the provisions of EN 1998 need not apply.

2.8. Hydrogeology

2.8.1. The site hydrogeology is summarised in Table 2.1 and the associated references listed at the rear of the report.

Table 2.1: Summary of Hydrogeology

Type	Description	Ref
Superficial/Drift Deposits	Secondary (undifferentiated)	[1]
Soil/Bedrock Deposits	Secondary A	
Soil Leaching Potential	Low risk	
Source Protection Zone	None within 2km	
Groundwater Abstractions	None within 1km of the site	

2.8.2. The site is considered to have a Moderate Sensitivity with respect to hydrogeology. The sensitivity is based upon the definitions provided in NHBC R&D66[1], as amended to include the requirements of the Water Framework Directive and the EA's River Basin Catchment Plans.

2.9. Hydrology

2.9.1. The site hydrology is summarised in Table 2.2 and the associated references listed at the rear of the report.

[1] Guidance for the Safe Development of Housing on Land Affected by Contamination R&D66: 2008 Volume 1 (Environment Agency, NHBC and CIEH)

Table 2.2: Summary of Hydrology

Type	Distance	Description	Ref
Surface Waters	Adjacent South	Unnamed Tributary of Brislington Brook	[1]
	330m W	Brislington Brook	
	600m E	River Avon	
Surface Water Abstractions	-	None present within 1km of the site	
Flooding	On site	Flood Risk Zone 1 (low risk)	

2.9.2. The site is considered to have a High Sensitivity with respect to hydrology. The sensitivity is based upon the guidance detailed for the hydrogeological assessment above.

2.10. Radon

2.10.1. The site is situated in a LOW risk area with respect to radon gas, with less than 1% of new residential dwellings requiring radon protection measures [1].

2.10.2. As such, no radon protection measures are required as part of the proposed development.

2.11. Sensitive Land Uses

2.11.1. A review has been made of statutory designated ecological and heritage sites and these are summarised in Table 2.3 below.

Table 2.3: Summary of Designated Sites

Type	Description	Ref
Ecological	Area of Adopted Green Belt area located 100m north east of the site.	[1]
	Ancient Woodland 300 – 900m east / north east / north of the site.	
	Eastwood farm LNR located 0.02km east includes a range of wildlife habitats including broadleaved woodland, wildflower rich meadows and water meadows	[10]
	Local Nature Reserve (LNR). Avon Valley Woodland. Source Natural England. Designation Date: 31st March 2005.	
	Bickley Wood SSSI, located 1.1km south of the site is designated for its geological interest.	
	Stockwood Open space LNR, located 1.2km south of the site comprises grassland and unploughed meadows on lime-rich clay soils, supporting a range of butterfly species	
	Callington Road LNR, located 1.3km west of Brislington Meadows and largely overlapping with Callington Road Site of Nature Conservation Interest (SNCI), comprising former allotments, meadows scrub and hedgerows	
	Troopers Hill LNR, located 1.6km north of Brislington Meadows and locally managed, including a locally unique area of acid grassland and heathland supporting populations of rare invertebrates such as mining bees and grassland fungi	
	Total of 24 SNCIs located within 2km of the Brislington Meadows, of which 15 are located within 1km	

Type	Description	Ref
	Land at Broomhill Junior School adjacent to the site in the north, the allotments adjacent to the site in the west, elements of Brislington Meadows SNCI to the southwest of the site, and the small amenity area to the south of Sinnott House are identified as Bristol Wildlife Network Sites (BWNS).	
	Avon Gorge Woodlands Special Area of Conservation is located approximately 6km northwest and is designated for its Tilio-Acerion forests of slopes, screes and ravines, semi-natural dry grasslands and scrubland facies on calcareous substrates. The underlying Avon Gorge Site of Special Scientific Interest (SSSI) is designated for its natural cliffs and quarry exposures of Carboniferous limestone, its ancient woodland, scrub, scree and grassland and an exceptional assemblage of nationally rare and scarce plant species.	
Heritage	36 designated heritage assets including two Conservation Areas, One Registered Park and Garden and 33 Listed Buildings of which 5 are Grade II* Listed. The proposed development site has been assessed as providing a minor positive contribution to the setting of the Avon Valley and Brislington Conservation Areas as representing the remains of former open field and enclosed landscape formerly bordering Brislington Common. 69 Non-designated heritage assets within the study area. Two are within or partly within the development site. These include remains of medieval ridge and furrow as well as the site of a former 19th century farmstead. The non-designated heritage assets which include prehistoric find spots, the site of a Roman Villa and find spots of the Roman Period and former built-heritage of the post-medieval period are considered to be of low or negligible heritage significance. 6 Hedgerows considered important under the Hedgerows Regulations Act but of low heritage significance.	[11]

3.0 SITE HISTORY AND INDUSTRIAL SETTING

3.1. Site History

3.1.1. The site is shown to be farmland in the area of Broom Hill from the earliest mapping (1884) [12]. This map showed the site to be sub-divided into 8 fields separated by hedgerows. Allotment gardens were present in plot 3 and adjacent land from circa 1955 until circa. 1967 with the Allotment gardens still present in the adjacent land. Allotment gardens were also present in plot 1 from circa. 1965 - 1988 and 1999 until present. Sinnot House Offices and car park were present on site from circa. 1999 until October 2020. Electricity Pylons were present on site from 1972 until present in the south of the site.

3.1.2. The earliest available maps show the settlement known as Rock was located to the west, Brislington to the southwest and Emery's Farm to the east. The Western Railway Tunnel is shown to the north east along with a number of air shafts in the vicinity of Earlswood Farm. Brislington House and grounds lay to the southeast. By 1938, the outline of a new neighbourhood of Broom Hill was shown.

3.1.3. Several Old Quarries were present 520m east of the site between circa. 1887 and 1946. Farm buildings were present adjacent to the north east of the site between circa. 1887 to 1967 which was later redeveloped into a commercial unit by circa. 1972 which has remained since. A cemetery located 240m south of the site is still present and was shown in mapping from circa. 1921. Victory Park adjacent to the south is shown from circa. 1932 until present. A school, currently Broomhill infant and Junior school was first shown on mapping from circa. 1965. Brislington Trading Estate is shown to the east of site from circa. 1965 and has remained present.

3.1.4. The site may generally be considered greenfield, with no historic development across the majority of the area, the only exception being former Allotment Gardens prior to the construction of the Sinnott House Police Station building and associated parking areas and in the north east of the site, which existed between circa. 1999 and October 2020.There is considered to be some limited potential for a residuum of contamination to be present in this area which is considered further in the intrusive investigation.

3.1.5. Coal measures are a known potential source of hazardous ground gases. Whilst a review of coal mining records and geological information indicates the nearest coal seam to be off site to the south west and to be dipping away from the site; the potential for gases to impact surrounding overlying areas. As such this has been targeted by the recently completed ground investigation.

3.2. Unexploded Ordnance (UXO)

3.2.1. A HIGH RISK was identified at the site by reference to Zetica bomb risk mapping [4] and as such a detailed UXO risk assessment was recommended.

3.2.2. The detailed UXO assessment completed by EOD Contracts Ltd in 2019, [5]. The report concluded that the main sources of UXO contamination posing a threat to site are air delivered ordnance bombs, sub-munitions/incendiaries, anti-aircraft ammunition and military usage with UXO likely at a maximum bomb depth of 8m below 1939 ground level. Several bomb craters were also shown in aerial photographs of the site. The detailed UXO risk assessment confirmed A HIGH RISK on site as identified by reference to the Zetica Bomb Risk Mapping. The following risk mitigation strategy was recommended for all phases of the project:

"*Communicating the risks, all stakeholders should be made aware of the UXO situation on the site and the possible impact it may have on the project works and day to day running of the district. Clients have a legal duty under the Construction Design & Management Regulations (CDM) and Health & Safety at Work legislation to provide designers and contractors with project specific information needed to identify hazards and risks associated with the design and construction work. The possibility that UXO may be encountered on site falls within the category of a significant risk and as such it should be addressed as early as possible in the lifecycle of the project.*

Further Planning: the risks posed by UXO should be brought to the attention of the Project Principal Designers and other individuals with a responsibility for project safety and operations at the site. The matter of UXO should be considered critical to project safety and one requiring high priority action.

UXO safety awareness training should be given at all levels of site personnel and selected individuals on the project staff with relevant responsibilities. A competent person as part of the project safety induction course should provide the awareness training. It should be reinforced with specific safety briefings and toolbox talks to individuals involved in conducting intrusive earthworks.

Project overview and responsibilities of those working on site with regard to duty of care and public safety.

UXO recognition and safety procedures to be followed on discovery of a suspicious object or the alarm being sounded.

Emergency procedures to be followed in the event of an explosion. Evacuation routes, muster stations and accounting for personnel

Work Permits, work methodology and specific UXO risk mitigation methods. Post-incident inspections and returning to normal works.

Prior to any intrusive piling or drilling commencing, UXO safety testing and appropriate clearance certification into the ground to sufficient depth to provide clearance from UXO. This can be done using a progressive drilling process or (where large numbers of piles are to be placed and ground permitting) using a vehicle borne hydraulic system to push a magnetometer into the ground to test for the presence of UXO prior to piling.

UXO safety monitoring of all "at risk" excavations, including geotechnical or archaeological trial pits to be conducted during the project. This should be provided by a UK Home Office Authorised EOD/UXO Contractor using qualified EOD Engineer with specialist locaters and detectors to scan the ground ahead of the excavation wherever possible.

Specifically:

- *Geotechnical investigations, percussive drilling/trial pits/ window samples, require an EOD Engineer over watch*
- *This site should warrant a Non-Intrusive Magnetometer survey and post analysis excavation of anomalies*
- *New foundations with piling could be mitigated by the insertion of a magnetometer to encompass the pile position, this would be carried out using a CPT rig (magcone), the expected radius of the magcone is 1.5m therefore multiple piles could be checked.*"

Non-intrusive Magnetometer Survey

3.2.3. A non-intrusive magnetometer survey was undertaken by Brimstone Site Investigation (BSI) between 14th and 16th April 2021. The Non-intrusive UXO Survey Report [6] is included within Appendix D.

3.2.4. The objective of the survey was to identify any possible buried UXO ahead of intrusive groundworks. The output of the survey produced a coordinated list of targets with estimated mass and depth. In total 281 targets were identified with the total number of targets reduced to 196 to reduce the risk level t as low as reasonably practicable. The report concluded that the depth range for UXO targets was between 0.55 – 1.6m bgl.

3.2.5. Following the non-intrusive survey, a targeted investigation of suspected buried objects was recommended.

Intrusive UXO Target Investigation

3.2.6. An intrusive target survey was carried out by BSI between 15th and 24th of November 2021 [7]. Of the 196 targets identified in the non-intrusive survey report 145 targets were investigated. 51 targets were inaccessible at the time of the investigation and will be investigated at a later date.

3.2.7. Of the 145 targets investigated no items of UXO were found. The report concluded that the site has been given clearance with the exception of the areas of site which contained the inaccessible targets.

3.2.8. This report will be will be updated upon completion of the final intrusive investigation. The Intrusive Target Survey Report is contained within Appendix D.

3.2.9. In addition, UXO risk mitigation measures were employed during the recently completed ground investigation works, and are recommended for future phases of intrusive ground works.

3.3. Tunnels and Infrastructure

3.3.1. From reference to CampbellReith's online database GISSMO, there are no recorded tunnels underlying the site.

3.3.2. Following a utilities search it was noted that the following services were within or close to the site boundary:

- Electricity cables and infrastructure
- Gas infrastructure
- Telecommunications cables
- A telecommunications mast
- Potable water infrastructure
- Foul water sewers
- Surface water sewers

3.3.3. Table 1 below provides a summary of Statutory Undertakers that were then consulted regarding record plans of their existing utility infrastructure close to and within the proposed site.

Table 1: Statutory Undertaker Contacts List

UTILITY TYPE	STATUTORY UNDERTAKER	EXISTING INFRASTRUCTURE
Electricity	Western Power Distribution (WPD)	✓
Gas	Wales and West Utilities (WWU)	✓
Storm and Foul Drainage	Wessex Water (WW)	✓
Potable Water	Bristol Water (BW)	✓
Telecoms	British Telecom (BT)	✓
Telecoms	Virgin Media (VM)	✓

3.4. Current Industrial Setting

3.4.1. Table 3.1 summarises identified industrial features, which may present a potential source of contamination at the site based upon the WSP report [1], which should be consulted for further details.

Table 3.1: Industrial Setting

Type	Distance Reviewed	Distance from Site	Description
Contaminated land register entries and notices	<500m	-	None recorded
Active Landfills	<250m	-	None recorded
Historic Landfills	<250m	-	None recorded
Waste Transfer/Treatment Stations	<100m	65m S	DG Hales, scrapyard authorised to store scrap cars, vehicles and components dated 1994.
Potentially Infilled Land	<250m	127m NE	
Pollution Incidents	<50m	-	None recorded
Environmental Permits	<150m	120m S	Local Authority Pollution Prevention and Control. Pitstop Garages Ltd, for waste oil burners. Dated 1993. Revoked.
Discharge Consents	<100m	55m NE	Operator: Wessex Water Services Ltd. Property Type: Storm Tank. CSO on Sewerage Network (Water Company). Location: Broomhill Road, Frome Bridge Bristol, BS4 4RZ. Authority: Environment Agency, South West Region. Catchment Area: Tidal Bristol Avon. Reference: 011327. Permit Version 2. Effective Date: 28th September 2010. Issue Date: 28th September 2010. Revocation Date: 7th January 2015. Discharge Type: Public Sewage: Storm Sewage Overflow. Discharge: Freshwater Stream / River. Receiving Water: Unnamed Watercourse. Status: Inactive Surrendered under EPR 2010.
Fuel Stations	<200m	-	None recorded

Type	Distance Reviewed	Distance from Site	Description
Contemporary trade directory entries - active	<100m	1 – 100m	MOT testing, recycling services, fire station, tank, car paint and lacquer manufacturers and suppliers.
Contemporary trade directory entries - inactive	<100m	0 – 100m	Car body repairs, plant and machinery repairs, garage services, waste disposal services – Oil and Water Limited, car body repairs.
Control of Major Accident Hazards (COMAH) Sites	<500m	-	None recorded

3.4.2. None of the information summarised in Table 3.1 is considered to alter the initial assessment of the site based on a review of historical mapping and the site reconnaissance undertaken, that being that the site presents a LOW risk in relation to potential contamination issues as presented in the WSP report [1].

4.0 PRELIMINARY CONCEPTUAL SITE MODEL & QUALITATIVE RISK ASSESSMENT

4.1. Introduction

4.1.1. Current practice for land contamination evaluation involves the classification of risk for identified contaminant source-pathway-receptor pollutant linkages. These are summarised below, considering the desk study information obtained. This information has been utilised to design the site investigation considering the proposed end use.

4.2. Classification of Risk

4.2.1. Risk is defined by the combination of two factors: i) the probability of an occurrence (expressed as a likelihood); and ii) the consequence of it happening (expressed as the severity). The procedure for classifying risk is summarised in Table 4.1.

4.2.2. The categories of risk have been based upon those defined in the Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D66: 2008 Volume 1 (Environment Agency, NHBC and CIEH).

4.2.3. The categories are defined in the Environmental Risk Assessment Supporting Information section to the rear of this report, together with definitions of the classifications of probability and consequence.

Table 4.1: Classification of Risk

Probability (Likelihood)		Consequence			
		Severe	Medium	Mild	Minor
	High likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

4.3. Potential Sources of Contamination

4.3.1. Table 4.2 summarises the potential contamination sources that were identified on or near the site based on a review of the WSP report [1].

4.3.2. The potential contaminant types associated with these is given based upon a review of CLR11, industry profiles and anecdotal information:

Table 4.2: Potential Sources of Contamination

Feature on or near site	Potential Contaminant
Made Ground associated with historic development (i.e. the area of Sinnot House in the north east)	M, H, PAH, ACM
Historic and active industrial land uses near to the site including	M, H, PAH, VOCs, SVOCs, ACM
Potential presence of coal seams beneath or near to the site	GG
Notes: M – Metals. H – Hydrocarbons. PAH – Polycyclic Aromatic Hydrocarbons. ACM – Asbestos containing Materials. GG – Ground Gases.	

4.4. Receptors and Exposure Pathways

4.4.1. Potential risks have been identified based on the proposed site use, the receptors and potential pathways by which the receptor/s may be exposed to the contaminant source/s.

4.4.2. These are presented in Table 4.3 and have been used to inform the site investigation.

Table 4.3: Receptors and Exposure Pathways

Receptor	Pathway	Risk
End Users	Ingestion of soil/dust	Low
Neighbours		Low
Construction Workers		Low
End Users	Inhalation of soil/dust	Low
Neighbours		Low
Construction Workers		Low
End Users	Dermal contact with soil/dust/water	Low
Neighbours		Low
Construction Workers		Low
End Users	Inhalation of vapour from soil/dust	Very Low
Neighbours		Very Low
Construction Workers		Very Low
End Users	Migration of soil gases to confined spaces/structures	Very Low
Construction Workers		Very Low
Building		Very Low
End Users	Inhalation of vapour from groundwater	Very Low
Neighbours		Very Low
Construction Workers		Very Low
Surface Waters	Migration of water borne contaminants from onsite	Very Low
Groundwater Aquifer	Migration of contamination from surface and/or subsurface to groundwater	Very Low
Groundwater Aquifer	Migration of water borne contamination from off-site	Very Low
End Users	Movement of contaminants to engineered structures (water pipes)	Low
Sensitive Land Use (SSSI etc)	Uptake by flora/fauna associated with sensitive land use	Very Low

4.4.3. The recently completed site investigation targeted the identified pollutant linkages, with laboratory analyses scheduled based on the potential contaminants of concern identified.

4.4.4. The findings of the intrusive investigation of the potential contaminant sources and pathways are reported herein. This has informed the Generic Quantitative Risk Assessment presented in Section 6.0 and the subsequent discussion of risk in Section 11.0.

5.0 SITE INVESTIGATION

5.1. Summary of 2020 Site Investigation

5.1.1. The 2020 site investigation was carried out by Geotechnical Engineering Limited (GEL) during their period 2nd November 2020 to 20th November 2020, their factual report is presented in Appendix C. The exploratory hole locations are presented on Figure 1 of the GEL factual report. The site work comprised:

- 6 no. rotary boreholes to 30m depth below ground level (bgl);
- 16 no. machine dug trial pits and 1 no. hand dug trial pit to a maximum depth of 5m bgl; and,
- 4 no. soakaway tests within separately dug trial pits.

5.1.2. The boreholes were formed using a dynamic continuous windowless sampler until refusal and then advanced to depth using rotary core drilling techniques to achieve the target depth. In BH01-02, BH04 and BH06 the boreholes were advanced from 14.70m using rotary open hole drilling techniques with a 70mm diameter tri-cone bit utilising water as a flushing medium. This technique was used in BH05 from 19.20m bgl.

5.1.3. The scope of the ground investigation undertaken at the site was primarily designed to inform the geotechnical evaluation of the ground conditions for site reprofiling, development platforms and foundation design for the proposed residential development as well as for environmental assessment.

5.1.4. The ground conditions encountered with respect to the monitoring installations are summarised in Table 5.1. Visits have been made to site on three occasions on 30th November and 12th December 2020 and 11th January 2021 to monitor gas and water levels within the installations and to obtain samples.

Table 5.1: Standpipe Summary

Exploratory Hole	Response Zone (m bgl)	Response Zone Strata	
BH 01	2.9-13.0	2.9 – 9.8	Sandstone
		9.8 – 12.3	Mudstone
		12.3 – 13.0	Sandstone
		5.0m	Refusal
BH 02	0.9 – 11.0	0.9 – 2.7	Weathered sandstone / mudstone
		2.7 – 11.0	Sandstone
BH 03	0.9 – 11.1	0.9 – 3.3	Weathered mudstone / sandstone
		3.3 – 5.7	Mudstone
		5.7 – 7.45	Sandstone
		7.45 – 7.8	Mudstone
		7.8 – 9.25	Sandstone
		9.25 – 10.9	Mudstone
		10.9 – 1.1	Sandstone
BH 04	0.9 – 11.0	0.9 – 2.1	Weathered sandstone

Exploratory Hole	Response Zone (m bgl)	Response Zone Strata	
		2.1 – 10.2	Mudstone
		10.2 – 11.0	Sandstone
BH 05	1.9 – 12.0	1.9 – 12.0	Sandstone
BH 06	0.9 – 9.0	0.9 – 2.9	Weathered mudstone / sandstone
		2.9 – 3.8	Mudstone
		3.8 – 5.5	Sandstone
		5.5 – 6.9	Mudstone
		6.9 – 9.0	Sandstone

Note: The strata given in Table 5.1 relate to those associated with the response zone to the installation, not the borehole as a whole.

5.2. Groundwater Observations

5.2.1. Groundwater monitoring was undertaken between 30th November 2020 and 11th January 2021. Water strikes observed during the site works and the results of the monitoring visits are summarised in Table 5.2 below.

Table 5.2: Groundwater Observations

Exp Hole	Water Strikes				Standing Water Level During Monitoring			
	Struck		Rose to		Shallowest		Deepest	
	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD	m bgl	m AOD
BH01	-	-	-	-	1.93	59.47	2.30	59.10
BH02	-	-	-	-	3.31	48.49	4.25	47.55
BH03	1.10	47.75	0.80	48.05	1.85	47.00	2.86	45.99
BH04	2.10	56.65	2.00	56.75	2.62	56.13	5.58	53.17
BH05	-	-	-	-	7.41	58.29	7.41	58.29
BH06	0.80	56.08	0.30	56.55	1.01	55.84	1.04	55.81
TP14	1.90	59.10	1.95	59.05	N/A			
TP15	0.50	60.80	0.50	60.80				
	1.60	59.70	1.60	59.70				
TP16	1.80	59.55	1.80	59.55				
SA01	2.50	44.95	2.50	44.95				
SA02	3.10	52.15	3.10	52.15				
SA03	1.80	55.20	1.80	55.20				
SA04	2.30	57.80	2.00	58.10				

5.2.2. Groundwater strikes were recorded in boreholes BH03, BH04 and BH06 each of which is located towards the area of lowest elevation in the south of the site. Groundwater strikes were also recorded in soakaway test pits SA01, SA02, SA03 and SA04 along the southern edge of the site. Strikes were also recorded in TP14, TP15 and TP16 at the north-eastern end of the site at the boundary where the sandstone meets the overlying sandstone gravel or perched within an overlying layer of clay.

5.3. Geotechnical Testing

5.3.1. No in-situ geotechnical testing was undertaken during the site investigation. Samples were obtained for appropriate laboratory analysis. Geotechnical testing is summarised in Table 5.3. Any limitations to the testing that require consideration during the evaluation of the data are described in the following paragraphs.

Table 5.3: Laboratory Tests (Geotechnical)

Test type and reference (BS 1377: 1990 unless stated)	Number
Water (Moisture) Content (Part 2:3.2/BS EN ISO 17892-1).	13
Liquid and plastic limits and plasticity index (Part 2:4.3, 5.3 and 5.4)	13
Particle size distribution - wet sieving (Part 2:9.2/BS EN ISO 17892-4)	14
Particle size distribution - sedimentation by pipette method (Part 2:9.4/BS EN ISO 17892-5)	1
Organic matter content (Part 3:3)	5
Compaction 2.5 (Part 4:3.3, 3.4)	3
Water soluble sulphate content 2:1 aqueous extract (BRE SD1 2005)	6
Total sulphur content (BRE SD1 2005)	6
Acid soluble sulphate content (BRE SD1 2005)	6
Soil pH (BRE SD1 2005)	6
Rock Water Content (I.S.R.M Suggested methods: 2007 Edition)	7
Point Load Test (I.S.R.M Suggested methods: 2007 Edition)	10

5.4. Contamination Observations and Testing

5.4.1. Olfactory and visual evidence of potential contamination is summarised in Table 5.4 and includes observations relating to organic materials that may indicate coal mining and a ground gas risk potential. Table 5.5 summarises the chemical suites that were analysed based upon the preliminary conceptual model and observed site conditions.

Table 5.4: Summary of Evidence of Contamination

Exploratory Hole	Depth (m bgl)	Comment	
BH01	2.20 – 5.50	Farrington and Barren Red Formation	Carbonaceous laminae
	9.85-9.95		Weak black coal
BH02	3.20 – 3.80	Farrington and Barren Red Formation	Carbonaceous laminae
	12.55- 14.70		Carbonaceous laminae
BH03	5.70 – 7.45	Farrington and Barren Red Formation	Carbonaceous laminae
	7.80 – 9.25	Farrington and Barren Red Formation	Carbonaceous laminae
	13.40 – 13.70	Farrington and Barren Red Formation	Carbonaceous laminae
BH04	9.70 – 10.00	Farrington and Barren Red Formation	Black coal laminae
	10.20 – 14.70	Farrington and Barren Red Formation	Carbonaceous laminae

Exploratory Hole	Depth (m bgl)	Comment	
BH06	2.00 – 2.90	Farrington and Barren Red Formation	Carbonaceous laminae

5.4.2. In general significant sources of contamination were not encountered during the intrusive site investigation. The Farrington and Barren Red Formation contain nominal thicknesses of coal and carbonaceous laminae, these have the potential to produce nominal concentrations of ground gases.

5.4.3. Table 5.5 summarises the chemical suites that were analysed by the laboratory based upon the pollutant linkages identified in the Preliminary Conceptual Site Model and observed site conditions:

Table 5.5: Laboratory Tests (Environmental)

Test type	Number
SOIL	
S1.1: CampbellReith Basic Soil Suite – pH, moisture content, phenols monohydric, total cyanide, arsenic, cadmium, chromium, nickel, lead, mercury, selenium, copper, zinc, speciated polyaromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (>C6-40 and C10-40).	19
S1.3: Asbestos in soil screening	14
S1.4: Total Organic Carbon (%)	3
WATER	
W1.1: CampbellReith Basic Water Suite – arsenic, cadmium, chromium, copper, nickel, zinc, lead, mercury, boron, selenium, copper, zinc, speciated (16) PAHs, total petroleum hydrocarbons (C10 – C40), phenols, total cyanide, free cyanide, thiocyanate, sulphate, sulphide and total sulphur.	6

5.5. Summary of 2022 Site Investigation

5.5.1. Following reports of waterlogged ground on the northern site boundary by The Environment Partnership in September 2020 during an ecological survey on site, a ground investigation was designed by CampbellReith. The site investigation was carried out by CC Ground Investigation Ltd in January 2022. Exploratory hole locations are shown in Appendix D, Figure 1.

5.5.2. The site works comprised four machine excavated trial pits to a maximum depth of 1.05m bgl. The logs are presented in Appendix D.

5.5.3. One water sample was collected from the waterlogged ground at TP03 prior to excavation. The sample was submitted for microbiological analysis of faecal indicators and the CampbellReith basic water suite chemical analyses. The Results of the microbiological and chemical analyses are presented in Appendix D.

5.5.4. During the course of the investigation a silted up and cracked land drain was encountered as the source of the waterlogged ground. Trial pits were terminated upon encountering the drain at the below depths:

- TP01 terminated at 0.75m bgl;
- TP03 terminated at 0.70m bgl; and,
- TP04 terminated at 0.70m bgl.

5.5.5. The damaged land drain was not encountered within TP02 and as such the trial pit was terminated at 1.05m bgl.

6.0 GENERIC QUANTITATIVE RISK ASSESSMENT

6.1. Assessment Framework

6.1.1. Subsequent to the identification and quantification of contaminant species in soils, waters and gases, it is necessary to select a method for assessing their significance in view of the current and proposed future use of the land. The initial assessment comprises comparison of identified contaminant levels to generic screening values that have been prepared to assess the risk to human, controlled water and gas risk receptors. The guidance used to provide this initial screening is listed in Table 6.1.

6.1.2. With respect to Human Health Risk Assessment the screening values for a residential with plant uptake end use as defined in Environment Agency Guidance SR3[2] have been selected based upon the proposed development of up to 260 residential properties with private gardens. The assessment assumes a Soil Organic Matter (SOM) content of 2.5% based on average site derived SOM data from the Made Ground of 2.69%.

6.1.3. Controlled Water Risk Assessment has been undertaken using as available Environmental Quality Standards (EQS) for the protection of aquatic life due to the presence of a drainage ditch on site that flows into the Brislington Brook located 330m west of the site. The specific legislation and/or guidance that dictate the water quality standards adopted are contaminant specific and these are referenced in the Summary of Water Analysis table. The water quality standards have been chosen in accordance with section 4.2 of the EA's Remedial Targets Methodology as informed by the EA's Groundwater Protection Guides (2017), and documents listed in Table 6.1[3].

6.1.4. For further detailed information on the current Regulations and selection of appropriate threshold values, please refer to the rear of this report text.

Table 6.1 Generic Quantitative Screening Values

	Key Guidance
Soil	LQM/CIEH S4ULs for Human Health Risk Assessment.*
	Defra Development of Category 4 Screening Levels Main Report and associated documents
	Environment Agency CLEA Version 1.06 software. Environment Agency Science Reports SC050021 SR2/SR3
	Generic Assessment Criteria based upon Environment Agency CLEA UK Beta Version 1.0.
Water	EA Groundwater Protection Guides, March 2017.
	The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
	Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2015
	EC and UK Drinking Water Standards.
	WHO Drinking Water Standards.
	Background Water Quality.
Gas	CIRIA C748, 'Guidance on the use of plastic membranes as VOC vapour barriers'.
	CIRIA C735, 'Good practice on the testing and verification of protection systems for buildings against hazardous ground gases'.

[2] Updated Technical Background to the CLEA Model, Science Report SC050021/SR3
[3] https://www.gov.uk/government/collections/groundwater-protection

	Key Guidance
	BS 8576:2013, 'Guidance on investigations for ground gas – permanent gases and VOCs'
	CIRIA Report C665, 'Assessing Risks Posed by Hazardous Ground Gases to Buildings'
	CIRIA Report C682, 'VOCs Handbook: investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination'
	British Standard BS:8485+A1:2019, 2015, 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings'.
	CIRIA Report 150 'Methane Investigation Strategies'.
	BRE 414 'Protective Measures for Housing on Gas Contaminated Land', 2001.
	The Building Regulations 2000, Approved Document C, Section 2. Updated 2004.
	BR211, 'Radon: Guidance on Protective Measures for New Buildings', 2015.
	Health Protection Agency Publication HPA RPD-033, 2007,' Indicative Atlas of Radon in England and Wales.

6.2. Soil

6.2.1. The results have been reviewed for evidence of potential zoning across the site and/or between the various soil strata. As a consequence, the statistical assessment has treated the site as a single averaging area and screened in its entirety. The assessment has included the upper 1.0m depth of the Made Ground or natural soil where Made Ground was not encountered. Additional tables are presented where appropriate to reflect distinct ground characteristics relevant to the conceptual model.

6.2.2. The statistics associated with soil analysis are summarised in Table 6.2. The Mean Value (95%ile) and Maximum Value Tests were undertaken on the sample population/s for those parameters exceeding the screening levels. Where the 95%ile exceeds the screening values, these results are highlighted and discussed. The remainder are not considered indicative of significant contamination for the proposed end use.

Table 6.2: Summary of Soil Analysis

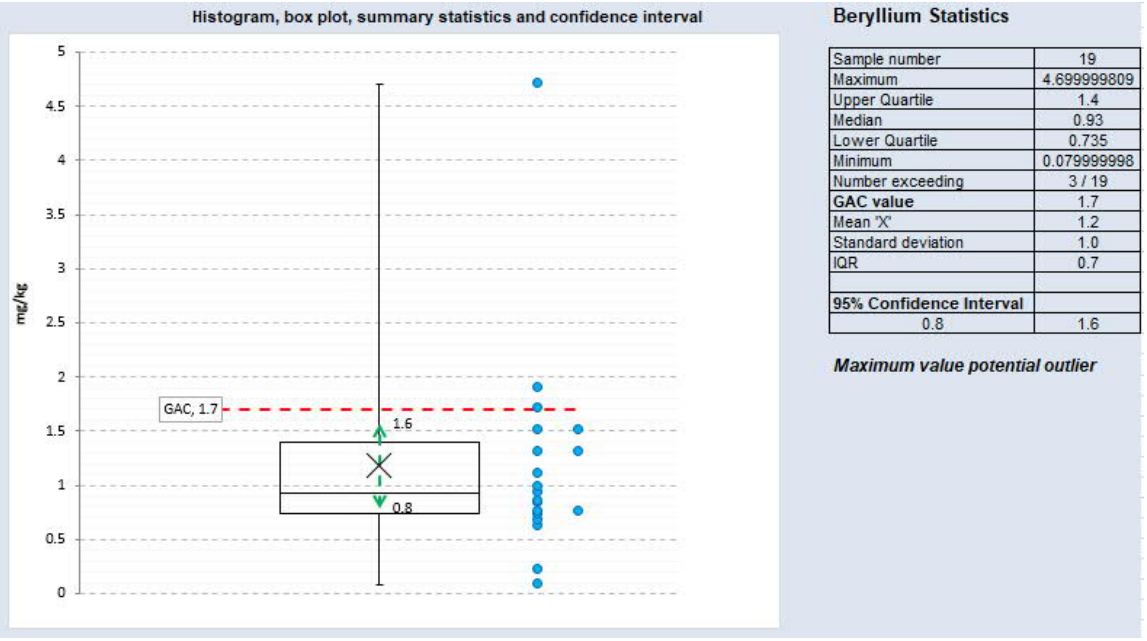
Contaminant	Units	Exceeding	Max	95% UCL	GAC
Metals & Inorganics					
Arsenic	mg/kg	0 / 19	24	-	37 [B]
Boron	mg/kg	0 / 19	0.8	-	530 [A]
Beryllium	mg/kg	3 / 19	4.7	1.57	1.7 [A]
Cadmium	mg/kg	0 / 19	1.2	-	22 [B]
Chromium	mg/kg	0 / 19	31	-	910 [A]
Copper	mg/kg	0 / 19	100	-	2900 [A]
Lead	mg/kg	1 / 19	470	126	200 [B]
Mercury	mg/kg	0 / 19	<0.3	-	42 [A]
Nickel	mg/kg	0 / 19	34	-	140 [A]
Selenium	mg/kg	0 / 19	2.5	-	270 [A]
Vanadium	mg/kg	0 / 19	63	-	480 [A]
Zinc	mg/kg	0 / 19	170	-	4800 [A]
Cyanide	mg/kg	0 / 19	<1	-	24 [C]
Total Petroleum Hydrocarbons					

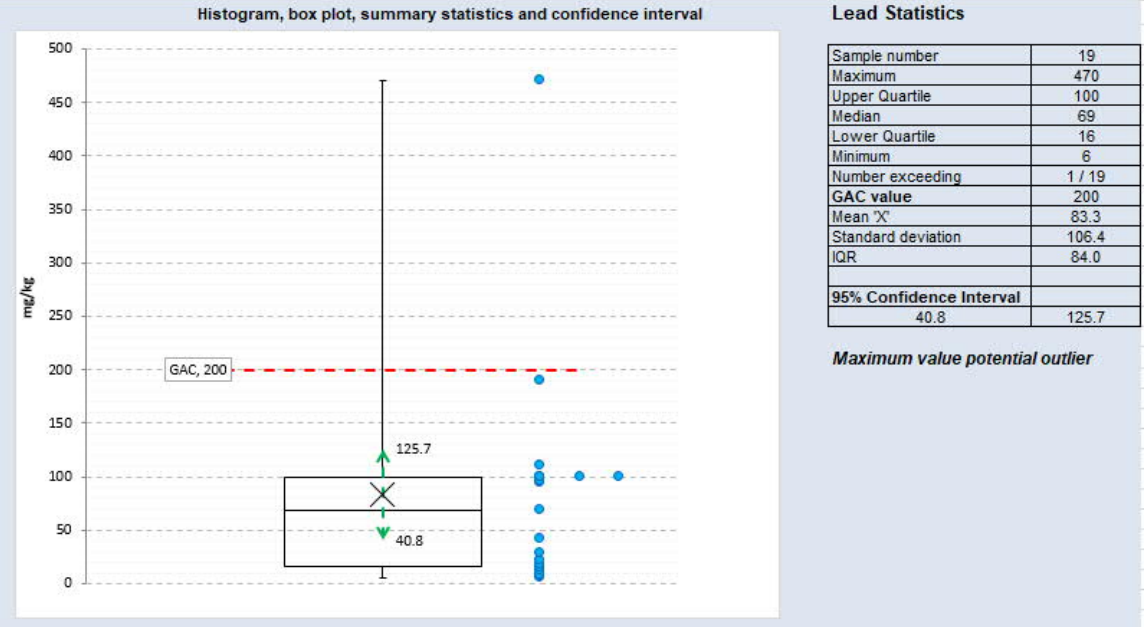
Contaminant	Units	Exceeding	Max	95% UCL	GAC
TPH >C6-40	mg/kg	2 / 19	98	33.2	65 [A]
EPH/TPH C6-10	mg/kg	- / 19	<0.1	-	n/a
TPH >C10-40	mg/kg	0 / 19	98	-	190 [A]
Polycyclic Aromatic Hydrocarbons					
Naphthalene	mg/kg	0 / 19	<0.05	-	5.6 [A]
Acenaphthylene	mg/kg	0 / 19	<0.05	-	460 [A]
Acenaphthene	mg/kg	0 / 19	<0.05	-	550 [A]
Fluorene	mg/kg	0 / 19	<0.05	-	440 [A]
Phenanthrene	mg/kg	0 / 19	2.6	-	240 [A]
Anthracene	mg/kg	0 / 19	0.31	-	5800 [A]
Fluoranthene	mg/kg	0 / 19	2.5	-	590 [A]
Pyrene	mg/kg	0 / 19	4.2	-	1300 [A]
Benzo (a) anthracene	mg/kg	0 / 19	1.8	-	11 [A]
Chrysene	mg/kg	0 / 19	1.4	-	23 [A]
Benzo (b) fluoranthene	mg/kg	0 / 19	0.89	-	3.3 [A]
Benzo (k) fluoranthene	mg/kg	0 / 19	0.64	-	93 [A]
Benzo (a) pyrene	mg/kg	0 / 19	1.2	-	5 [B]
Indeno (1,2,3 - cd) pyrene	mg/kg	0 / 19	0.35	-	37 [A]
Dibenzo (ah) anthracene	mg/kg	0 / 19	<0.05	-	0.29 [A]
Benzo (ghi) perylene	mg/kg	0 / 19	0.47	-	340 [A]
Speciated Phenols					
Phenol (Monohydric)	mg/kg	0 / 19	<1	-	230 [A]

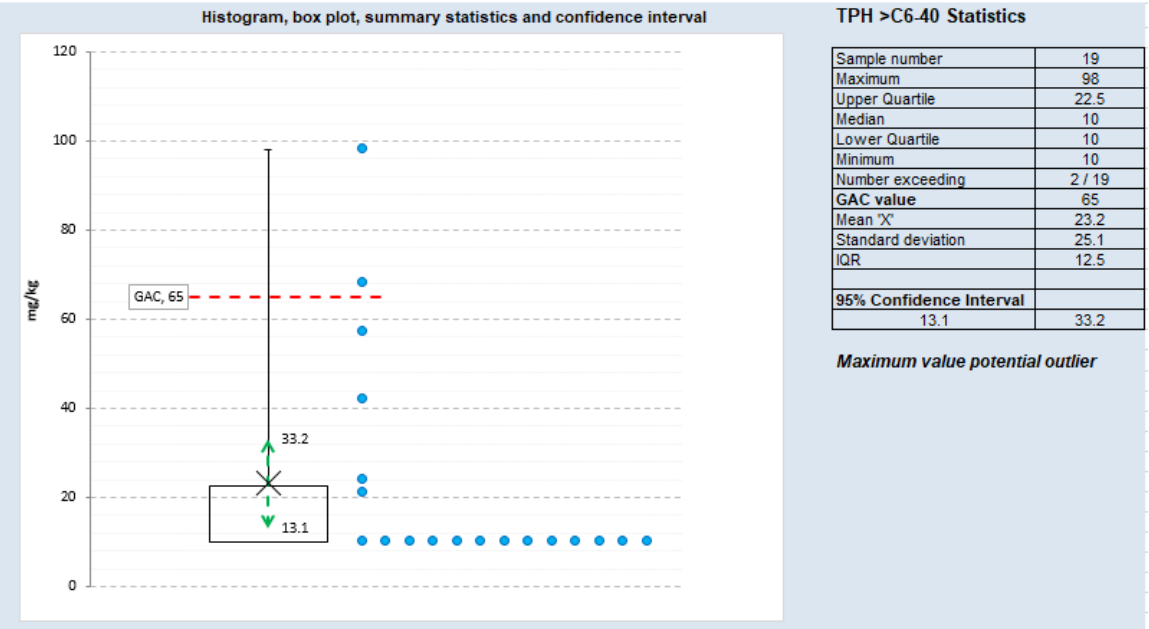
Residential with plant uptake assuming 2.5% SOM Generic Assessment Criteria (GAC). [A]LQM/CIEH Suitable for use Levels (S4UL). Copyright Land Quality Management reproduced with permission: Publication Number S4UL 3036. All rights reserved. Top two consumption group applied. [B]Defra Category 4 Screening Levels (C4SLs). [C]Acute Risk GAC (SoBRA derived).

6.2.3. Exceedances of beryllium, lead and total petroleum hydrocarbons (>C6-40) have been identified during the screening summarised in Table 8.2. In accordance with guidance on applying statistics to land contamination decision-making, CL:AIRE (2020), the results for contaminants exceeding the screening criteria have been plotted on a box plot and table of associated statistics.

Figures 6.1 - 6.3: Statistical Summary of Beryllium, Lead and TPH (>C6-40) Concentrations







6.2.4. Nominal beryllium exceedances were encountered at BH03 at 0.40m bgl, BH06 at 0.40m bgl and TP06 at 0.70m bgl. The 95%ile value is below the respective Tier 2 Screen and on the basis of Figure 8.1 it is clear that the bulk of the sample population is also below this. Given that all three samples were taken from natural soils and no obvious sources of beryllium contamination were recorded in the individual borehole logs, the elevated concentrations of beryllium are not considered to pose a risk.

6.2.5. A single nominal lead exceedance was encountered in BH04 at 0.40m bgl. The 95%ile value is below the respective Tier 2 Screen and on the basis of Figure 6.2 it is clear that the bulk of the sample population is well below this. Given that the sample was taken in natural soil and no obvious sources of lead contamination were recorded in the borehole log, the elevated concentration of lead is not considered to indicate elevated concentrations of lead and therefore soil lead concentrations are no considered to pose a risk to human health.

6.2.6. Two elevated concentrations of TPH (>C6-C40) were encountered in BH401 at 0.40m bgl and TP15 at 0.20m bgl. The 95%ile value is below the respective Tier 2 Screen and on the basis of Figure 6.3 it is clear that the bulk of the sample population were well below the respective GAC or below the limit of detection. The most elevated hydrocarbon concentrations was collected from an area of Made Ground (TP15) which occupy a very limited area of the site. The logs indicate the overlying strata to be tarmacadam, which is likely to be the source of the elevated concentration as no obvious sources of hydrocarbons were recorded in the underlying strata from which the sample was collected. In addition TP15 is under an area of hardstanding to be used as an access road under the proposed development. The sample collected in BH04 was taken from natural soils with no obvious signs of hydrocarbon contamination recorded in the individual borehole log. On the basis of the above TPH are not considered to pose a risk.

6.3. Asbestos

6.3.1. It is noted that there are no UK generic quantitative assessment criteria for asbestos in soils. A summary of the results for asbestos is presented below. Additional guidance on this topic is presented in CIRIA C733.

6.3.2. No visually identifiable asbestos was observed in any of the boreholes during the intrusive investigation. Asbestos was not detected in any of the 14 no. samples scheduled for testing.

6.4. Groundwater

6.4.1. Groundwater samples were obtained from water residing in the Farrington and Barren Red formation from BH01-04 and BH06 during the first monitoring visit on 30th November and from BH05 during the second monitoring visit on 17th December 2020. Visual or olfactory evidence of groundwater contamination was not observed during the monitoring visit.

6.4.2. The results of the groundwater analyses have been compared to the values contained within the references detailed in Table 4.1 for water quality. The selection of EQSs Standards is considered appropriate given the presence of a drainage ditch on site that flows into the Brislington Brook located 330m west of the site. The statistics associated with groundwater analysis are summarised in Table 6.5.

Table 6.5: Summary of Water Analysis

Contaminant	Units	Exceeding	Max	Mean	GAC
Metals & Inorganics					
Arsenic	µg/l	0/ 6	1.86	-	50[B*]
Boron	µg/l	0/ 6	210	-	2000[C]
Cadmium	µg/l	1/ 6	0.22	0.06	0.08[B]
Chromium	µg/l	0/ 6	2.7	-	4.7[B]
Chromium - Hexavalent	µg/l	6/ 6	<5	5.00	3.4[A*]
Copper	µg/l	6/ 6	6.5	3.47	1[B#]
Lead	µg/l	1/ 6	1.7	0.45	1.2[B*#]
Mercury	µg/l	0/ 6	0.07	-	0.07[B*]
Nickel	µg/l	5/ 6	16	8.28	4[B#]
Selenium	µg/l	1/ 6	15	3.35	7.5[A]
Zinc	µg/l	1/ 6	11	5.95	10.9[B#]
Cyanide	µg/l	0/ 6	<1	-	1[B]

Contaminant	Units	Exceeding	Max	Mean	GAC
Cyanide Free	µg/l	- / 6	<1	-	n/a
Thiocyanate	µg/l	- / 6	<200	-	n/a
Total Petroleum Hydrocarbons					
TPH >C10-40	µg/l	1/ 6	84	22.33	74[B]
Polycyclic Aromatic Hydrocarbons					
Naphthalene	µg/l	0/ 6	<0.01	-	2[B]
Acenaphthylene	µg/l	- / 6	<0.01	-	n/a
Acenaphthene	µg/l	- / 6	<0.01	-	n/a
Fluorene	µg/l	- / 6	<0.01	-	n/a
Phenanthrene	µg/l	- / 6	<0.01	-	n/a
Anthracene	µg/l	0/ 6	<0.01	-	0.1[B*]
Fluoranthene	µg/l	6/ 6	<0.01	0.01	0.0063[B*]
Pyrene	µg/l	- / 6	<0.01	-	n/a
Benzo (a) anthracene	µg/l	- / 6	<0.01	-	n/a
Chrysene	µg/l	- / 6	<0.01	-	n/a
Benzo (b) fluoranthene	µg/l	- / 6	<0.01	-	n/a
Benzo (k) fluoranthene	µg/l	- / 6	<0.01	-	n/a
Benzo (a) pyrene	µg/l	6/ 6	<0.01	0.01	0.00017[B*]
Indeno (1,2,3 - cd) pyrene	µg/l	- / 6	<0.01	-	n/a
Dibenzo (ah) anthracene	µg/l	- / 6	<0.01	-	n/a
Benzo (ghi) perylene	µg/l	- / 6	<0.01	-	n/a
PAH, Total Detected USEPA 16	µg/l	- / 6	<0.16	-	n/a
Speciated Phenols					
Phenol	µg/l	0/ 6	<0.5	-	7.7[B]
Total Speciated Phenols	µg/l	0/ 6	<3.5	-	7.7[B]

Sources of Generic Assessment Criteria: Environmental Quality Standards – rivers and lakes. [A]River Basin Districts Typology, Standards and Groundwater threshold values (WFD) (England and Wales) Directions 2010. [B]The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015. [C] Supporting Guidance (WAT-SG-53), Environmental Quality Standards and Standards for Discharge to Surface Waters. V6.1, SEPA, Feb 2018. *hazardous substance (according to Groundwater Directive 2006/118/EC). #assumes 100% bioavailability.

Metals

6.4.3. It should be noted that the limit of detection for hexavalent chromium exceeds the respective GAC. Detectable concentrations were not encountered. Visual evidence or an obvious source were not identified during the ground investigation. As such, hexavalent chromium is not considered to pose a risk.

6.4.4. Single marginal exceedances of cadmium, lead, selenium and zinc were encountered in BH03, BH06, BH01 and BH05 respectively. The mean concentrations of each of the contaminants did not exceed the respective GACs. In addition, significant soil concentrations were not encountered and obvious sources of contamination were not recorded in the borehole logs. Given the nominal nature of the isolated exceedances, the aforementioned contaminants are not considered to pose a risk to controlled water receptors.

6.4.5. Exceedances of copper were encountered in all six borehole locations. The maximum concentration (6.50 µg/l) and the mean concentration (3.47 µg/l) marginally exceeded the respective GAC value (1.00 µg/l). Significant copper concentrations were not encountered in the soil analysis and an obvious source of copper contamination was not identified in the borehole logs. Despite the mean concentration exceeding the respective GAC the concentrations are nominal and relatively consistent across all boreholes. Given the absence of an obvious source of copper contamination and the consistent and nominal nature of the exceedances it is likely that the concentrations encountered

are representative of local levels, and, as such are not considered to pose a risk to controlled water receptors.

6.4.6. Exceedances of nickel were encountered in all borehole locations excluding BH02. The maximum concentration (16.00 µg/l) and mean concentration (8.28 µg/l) exceeded the respective GAC. Significant nickel concentrations were not encountered in the soil analysis across the site and obvious sources of nickel contamination were not recorded in the borehole logs. Although elevated the concentrations are not indicative of a source of gross contamination and are likely to reflect the natural background nickel concentrations. Given the above, nickel concentrations are not considered to pose a risk to controlled water receptors.

Organics

6.4.7. The limit of detection for fluoranthene and benzo (a) pyrene both exceed the respective GAC. Detectable concentrations of either contaminant were not encountered. In addition, no visual or olfactory evidence was encountered during the intrusive works or the monitoring visits. As such fluoranthene and benzo (a) pyrene are not considered to pose a risk to controlled water receptors.

6.4.8. A single nominal TPH (>C10-40) exceedance (84.00 µg/l) was encountered in BH06. The groundwater analysis mean concentration (22.33 µg/l) for TPH (>C10-40) was well below the respective GAC value (74 µg/l). In addition no visual or olfactory evidence of hydrocarbon contamination was identified across the site. As such TPH concentrations are not considered to pose a risk to controlled waters.

6.5. Ground Gas

6.5.1. Three visits to monitor ground gas were undertaken between the 30th November 2020 and 11th January 2021. Recorded barometric pressures ranged between 1021mB on 30th November 2020 and 1009 on 17th December 2020. All six of the installations contained response zones that extended into the Farrington and Barren Red Formation.

6.5.2. It is noted that BH05 was not monitored during the second monitoring visit on 17th December 2021 as the installation required repair.

6.5.3. The notable pre-purge results, where steady state carbon dioxide exceeded 1.5%, methane 1% and/or oxygen fell below 18%, are summarised in Table 6.6.

Table 6.6: Summary Gas Concentrations and Flow Rates

Borehole	Date	Gas Concentration (%)			ppm	Average Flow Rate (l/hr)
		CO_2	CH_4	O2	VOCs	
BH04	30/11/2020	2.2	-	1.4	-	0.0
BH05		-	-	17.2	-	-1.2
BH06		-	-	-	-	0.7
BH01	17/12/2020	-	-	-	3.3	-0.2
BH02		-	-	11.4	1.6	0.0
BH03		2.4	-	12.7	-	6.5
BH04		1.6	-	5.6	1.0	0.5
BH06		-	-	-	-	-0.7
BH01	11/01/2021	4.9	-	5.7	-	-0.2

Borehole	Date	Gas Concentration (%)			ppm	Average Flow Rate (l/hr)
		CO_2	CH_4	O2	VOCs	
BH02		-	-	16.8	-	0.0
BH03		3.9	-	9.5	-	9.4
BH04		2.4	-	7.1	0.2	0.0
BH05		1.6	-	14.8	-	0.8

All percentage figures are by measurement of volume. '-' Results do not exceed thresholds.

6.5.4. Detectable concentrations of methane were not encountered during any of the three monitoring visits.

6.5.5. Marginally elevated carbon dioxide concentrations were encountered during all three monitoring visits in various boreholes. Steady state concentrations ranged from 1.6% v/v in BH04 on 17th December 2020 and BH05 on 11th January 2021 and 4.9% v/v encountered in BH01 on 11th January 2021.

6.5.6. Depressed oxygen concentrations were encountered in several boreholes during all three monitoring visits. The concentrations encountered ranged from 1.4% v/v in BH04 and 17.2% v/v encountered on the 30th November 2020.

6.5.7. Nominal concentrations of VOCs were encountered at several locations during the monitoring visits on 12th December 2021. Concentrations ranged from 1.0ppm in BH04 and 3.3ppm in BH01. A single nominal concentration of 0.2ppm was encountered within BH04 on the final monitoring visit. Olfactory or visual evidence of organic contamination was not observed during the investigation and significant hydrocarbon concentrations were not encountered in the soil or groundwater analysis. As such, the concentrations identified during monitoring are not considered to be significant.

6.5.8. Detectable concentrations of hydrogen sulphide were not encountered during any of the monitoring visits. As such hydrogen sulphide is not considered to pose a risk to end users.

6.5.9. Carbon monoxide concentrations were encountered within BH06 during the monitoring visit on 30th November. Steady state concentrations were not established however the concentrations recorded peaked at 31ppm and decreased to 15ppm across 4 minutes at the end of the monitoring period. If monitoring was continued it is likely that carbon monoxide concentrations would have decreased further. In addition, detectable steady state carbon monoxide concentrations were not encountered across the final two monitoring visits. Given that elevated concentrations were only encountered once and that they did not exceed the CIRIA Report C665 short term (350ppm) and long term (10,000ppm) environmental assessment levels (EALs), carbon monoxide is not considered to pose a risk to end users.

6.5.10. Steady state flow rates were generally not recorded above 0.8 l/hr during monitoring visits. The highest flow rates were encountered were in BH03 during the final two monitoring visits; 6.5 l/hr and 9.4 l/hr. It should be noted that these flow rates were decreasing and had not stabilised. It is likely that over a longer monitoring period these would have decreased further. In addition, it is noted that groundwater was present across the three monitoring visits which can cause positive or negative pressures / flows. The high flow rates in BH03 are not suggested as a result of gas generation, given the absence of significantly elevated gas concentrations at this location and the lack of significant Made Ground or natural sources of ground gas across the site as a whole. In addition, BH03 is located away from the residential properties in the Brislington Wetlands area under

the proposed development. As such, flow rates recorded at BH03 will not be used in the calculation of the Gas Screening Value (GSV) as they are not considered to be representative of the site and in particular the area where end users and buildings are most at risk. To be pragmatic the next worst case scenario values are used in the calculation of the GSV.

6.5.11. Based upon the guidance presented in Table 4.1, a preliminary assessment has been made of the requirements for gas protection that consider sources of gas generation, potential exposure routes, and applicable, representative gas flows and concentrations. This is summarised below:

- Potential on-site source of generation. No significant source of ground gases identified on site.
- Potential off-site Source of generation. Made Ground local to the site.
- Representative Concentrations and Gas Flows. In place of the omitted data collected from BH03, the next most elevated flow rate of 0.8 l/hr and a carbon dioxide concentration of 1.6% v/v will be used to calculate the GSV.
- Exposure Routes. Gas at the site primarily present a concern following ingress into confined spaces both during and after construction.

6.5.12. The Gas Screening Value (GSV) has been calculated using the worst case, representative ground gas concentrations and flow rate of 1.6% v/v and 0.8 l/hr from BH05, which is located adjacent to one of the residential building footprint under the proposed development. The GSV of 0.013 l/hr indicates the site is classified as a CIRIA Characteristic Situation 1 and as such protection measures are not required.

7.0 WASTE SOILS

7.1. Hazardous Properties

7.1.1. A formal hazardous properties assessment has not been carried out but the results of the investigation can be used to inform the likely classification of waste soils for disposal. A separate assessment is required for this purpose based upon technical guidance on classification of hazardous waste (Environment Agency: Guidance on the Classification and Assessment of Waste Technical Guidance WM3 Version 1.1, May 2018).

7.2. Asbestos

7.2.1. Asbestos is not included in the HazWasteOnline assessment. If the waste contains fibres that are free and dispersed then the waste will be hazardous if the waste as a whole contains 0.1% or more asbestos. Also, if waste contains identifiable pieces of asbestos containing material (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is regarded as hazardous.

7.2.2. Asbestos was not encountered in any of the fourteen samples scheduled for testing. As such, the samples would be considered non-hazardous in relation to asbestos.

7.3. Inert Soils Description

7.3.1. Uncontaminated natural soils would be considered inert by merit of their visual description and would be expected to be described under EWC 17-05-04 (soil and stones other than those mentioned in 17 05 03).

7.3.2. With respect to non-hazardous Made Ground soils there is a requirement to carry out analysis for Waste Acceptance Criteria (WAC - see below) to inform whether the soils may be suitable for disposal as inert waste; however, for those soils that contain anthropogenic inclusions an assessment of the inclusions is also required in order to determine potential suitability for classification as inert waste, regardless of the WAC result.

7.3.3. Inert waste is defined within the Landfill (England and Wales) Regulations 2002 (as amended) and the EEC Council Decision 2003/33/EC. ‘Soils and Stones’ can be judged inert where they exclude contamination, topsoil and peat. However, “If the listed wastes are contaminated or contain other material or substances such as metals, asbestos, plastics, chemicals, etc. to an extent which increases the risk associated with the waste sufficiently to justify their disposal in other classes of landfills, they may not be accepted in a landfill for inert waste" (excerpt from Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (2003/33/EC).

7.3.4. The logs indicate that the Made Ground soils are largely free of ‘metals, asbestos, plastics, chemicals, etc. to an extent which increases the risk’ and hence may be suitable for disposal as inert waste provided the WAC results indicate suitability. However, it will be necessary to inspect soils proposed for inert disposal and confirm this position with the landfill.

7.4. Waste Compliance: WAC Results

7.4.1. Waste Acceptance Criteria (WAC) results have been not been obtained. WAC results are indicative of whether pre-classified soils are acceptable at inert of hazardous landfill based on solid and leachate criteria (there are no WAC for non-hazardous landfills).

7.4.2. Landfill WAC analysis (specifically leaching test results) must not be used for waste classification and hazardous waste assessment purposes. This analysis is only applicable for landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

7.5. Landfill Tax

7.5.1. With respect to soils disposal at landfill reference should be made to HMRC Excise Notice LFT1: a general guide to Landfill Tax to determine the appropriate rate of landfill tax. There are two rates of tax, both of which are charged on a per weight basis: the lower rate applies to those less polluting wastes listed in the Landfill Tax (Qualifying Material) Order 2011, as amended, and the standard rate applies to all other taxable waste.

7.5.2. The only determining factor as to whether waste is lower rated is whether it is listed in the Landfill Tax (Qualifying Material) Order 2011. Whether or not waste is considered to be inert for environmental protection purposes is not relevant to matters of tax liability and a separate assessment should be made for this as the cost differential is significant. Equally, the fact that waste is listed in the Landfill Tax (Qualifying Material) Order 2011 does not mean that the waste is inert for environmental protection purposes.

8.0 ADDITIONAL TRIAL PITTING 2022 GROUND INVESTIGATION

8.1. Groundwater analysis

8.1.1. The source of the waterlogged ground was identified to be a 'land-drain', which was encountered at the base of trial pits: TP01, TP03 and TP04.

8.1.2. A single groundwater sample was obtained from the groundwater pooling at the location of TP03 prior to excavation.

8.1.3. The sample was submitted for both microbiological and chemical analyses. The results of the groundwater analysis have been compared to the values contained within the references detailed in Table 6.1 for water quality. The selection of EQSs for the protection of aquatic life is considered appropriate given the presence of a drainage ditch which flows into Brislington Brook 330m west of the site. The statistics associated with the chemical analysis are summarised in Table 8.1.

TABLE 8.1: Summary of Water Analysis

Contaminant	Units	Exceeding	Max	GAC
Arsenic	µg/l	0/ 1	0.42	50[B*]
Boron	µg/l	0/ 1	53	2000[C]
Cadmium	µg/l	0/ 1	0.03	0.08[B]
Chromium	µg/l	0/ 1	1.4	4.7[B]
Chromium – Hexavalent	µg/l	1/ 1	<5	3.4[A*]
Copper	µg/l	1/ 1	2.4	1[B#]
Lead	µg/l	0/ 1	0.3	1.2[B*#]
Mercury	µg/l	0/ 1	<0.05	0.07[B*]
Nickel	µg/l	0/ 1	1.7	4[B#]
Selenium	µg/l	0/ 1	4.1	7.5[A]
Zinc	µg/l	0/ 1	5.1	10.9[B#]
Cyanide	µg/l	1/ 1	<10	1[B]
Ammoniacal Nitrogen as N	µg/l	0/ 1	33	300[B]
Sulphate as SO4	µg/l	0/ 1	23600	400000[C]
Aliphatics >C5-6	µg/l	0/ 1	<1	15000[y]
Aliphatics >C6-8	µg/l	0/ 1	<1	15000[y]
Aliphatics >C8-10	µg/l	0/ 1	<1	300[y]
Aliphatics >C10-12	µg/l	0/ 1	<10	300[y]
Aliphatics >C12-16	µg/l	0/ 1	<10	300[y]
Aliphatics >C16-21	µg/l	0/ 1	<10	100[x]
Aliphatics >C21-35	µg/l	0/ 1	<10	100[x]
Aliphatics >C5-35	µg/l	0/ 1	<10	300[y]
Aromatics >C5-7	µg/l	0/ 1	<1	10[B]
Aromatics >C7-8	µg/l	0/ 1	<1	74[B]
Aromatics >C8-10	µg/l	0/ 1	<1	30[A]
Aromatics >C10-12	µg/l	1/ 1	<10	2[B]
Aromatics >C12-16	µg/l	0/ 1	<10	90[y]
Aromatics >C16-21	µg/l	0/ 1	<10	90[y]
Aromatics >C21-35	µg/l	0/ 1	<10	90[y]
Aromatics >C6-35	µg/l	0/ 1	<10	74[B]

Contaminant	Units	Exceeding	Max	GAC
Benzene	µg/l	0/ 1	<1	10[B*]
Toluene	µg/l	0/ 1	<1	74[B]
Ethylbenzene	µg/l	0/ 1	<1	20[C*]
O-Xylene	µg/l	0/ 1	<1	30[A]
m,p xylenes	µg/l	0/ 1	<1	30[A]
Methyl tert-butyl ether	µg/l	- / 1	<1	n/a
Naphthalene	µg/l	0/ 1	<0.01	2[B]
Acenaphthylene	µg/l	- / 1	<0.01	n/a
Acenaphthene	µg/l	- / 1	<0.01	n/a
Fluorene	µg/l	- / 1	<0.01	n/a
Phenanthrene	µg/l	- / 1	<0.01	n/a
Anthracene	µg/l	0/ 1	<0.01	0.1[B*]
Fluoranthene	µg/l	1/ 1	<0.01	0.0063[B*]
Pyrene	µg/l	- / 1	<0.01	n/a
Benzo (a) anthracene	µg/l	- / 1	<0.01	n/a
Chrysene	µg/l	- / 1	<0.01	n/a
Benzo (b) fluoranthene	µg/l	- / 1	<0.01	n/a
Benzo (k) fluoranthene	µg/l	- / 1	<0.01	n/a
Benzo (a) pyrene	µg/l	1/ 1	<0.01	0.00017[B*]
Indeno (1,2,3 - cd) pyrene	µg/l	- / 1	<0.01	n/a
Dibenzo (ah) anthracene	µg/l	- / 1	<0.01	n/a
Benzo (ghi) perylene	µg/l	- / 1	<0.01	n/a
PAH, Total Detected USEPA 16	µg/l	- / 1	<0.16	n/a
Phenol (Monohydric)	µg/l	1/ 1	<10	7.7[B]

Sources of Generic Assessment Criteria: Environmental Quality Standards – rivers and lakes. [A]River Basin Districts Typology, Standards and Groundwater threshold values (WFD) (England and Wales) Directions 2010. [B]The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015. [C]Supporting Guidance (WAT-SG-53), Environmental Quality Standards and Standards for Discharge to Surface Waters. V6.1, SEPA, Feb 2018. *hazardous substance (according to Groundwater Directive 2006/118/EC). #assumes 100% bioavailability.

8.1.4. The limit of detection for hexavalent chromium, cyanide, >C10-12 Aromatics, fluoranthene and benzo (a) pyrene and monohydric phenol exceed the respective GACs. Detectable concentrations were not encountered and obvious sources of contamination were not identified during the intrusive works. As such these contaminants are not considered to pose a risk to controlled water receptors.

8.1.5. A single nominal exceedance of copper was identified in the laboratory analysis. No obvious sources of contamination were recorded in the borehole logs. In addition, nominal exceedances of copper were also encountered in the groundwater samples collected during the 2020 ground investigation. As such contaminant concentrations encountered in the 2022 investigation are not considered to pose a risk to controlled water receptors.

9.0 GEOTECHNICAL EVALUATION

9.1. Ground Conditions

9.1.1. The ground conditions encountered during the site investigation generally consisted of mudstone and sandstone of the Farringdon and Barren Red Formation, which are locally weathered to a residual clay at discreet areas across the site but are predominantly unweathered, competent and are present at shallow depth. Potential Head material was encountered at the northern edge of the site towards Broomhill Road as was Made Ground. The general distribution of each stratum is shown in Table 9.1.

Table 9.1: Soil Profile

Stratum		From		To		Thickness (m)
		(m bgl)	(m AOD)	(m bgl)	(m AOD)	
Topsoil		0		0.7		0.15 – 0.7
Made Ground		0		0.4		0.1 – 0.35
Head deposits		0.3		1.1		0.3 – 0.8
Farrington and Barren Red	Residual bedrock (clay)	0.15		3.33		0.3 – 1.15
	Sandstone	0.15		30		0.1 – 15.3
	Mudstone	2.1		12.55		0.35 – 2.5
	Coal	9.7		10		0.05 – 0.1

9.1.2. The ground model as encountered in Table 9.1 broadly agrees with the conditions anticipated. Sandstone and mudstone of the Farringdon and Barren Red Formation is present across the site at a shallow depth forming a largely competent founding material. There are however discreet pockets within the site where the formation has been highly weathered resulting in areas of cohesive and compressible ground. Areas of weathered bedrock at shallow depths excavated as sand and gravel are also present. While the site is located within a coal mining area no significant coal seams were encountered. Three thin layers of coal between 0.05m and 0.1m thick were encountered however these indicate the productive seams within the region have thinned out before passing beneath the site. No evidence of mine workings or coal excavation was encountered during the site investigation.

9.2. Deposits

Topsoil

9.2.1. Topsoil was encountered in 23 exploratory holes at depths of between ground level and 0.7m bgl with range in thickness of 0.15m (TP13) to 0.7m (SA02). The material is generally described as a reddish brown or brown slightly clayey, slightly gravelly silty fine to coarse sand or sandy silty clay with gravel of sub-angular to sub-rounded fine to coarse sandstone.

Head Deposits

9.2.2. Head Deposits were encountered in three exploratory holes at depth of between 0.3m bgl and 1.1m bgl with a range in thickness of 0.3m (TP14) to 0.8m (TP15). The material is generally described as a yellowish brown slightly gravelly fine to coarse sand or a firm orangish brown slightly sandy slightly gravelly silty clay with a gravel of sub-angular fine to medium flint. The material is limited to the strip of land in the northeast of the site adjacent to Broomhill Road.

Made Ground

9.2.3. Made ground was encountered in three exploratory holes at depths of between ground level (61.35m OD TO 61.00m AOD) and 0.4m bgl (61.60m AOD) with a range in thickness of 0.30m (TP15) to 0.40m (TP16). The material is generally described as a grey and pinkish brown or brown slightly gravelly sandy silty clay with a gravel of sub-angular and sub-rounded fine to coarse limestone chert, brick and concrete with a high cobble content and rare fragments of plastic. The material is limited to the strip of land in the northeast of the site adjacent to Broomhill Road known as Sinnot House area.

9.2.4. A single Moisture Content test recording a value of 31% was undertaken on a sample of Made Ground from TP16 at 0.10m bgl (61.35m AOD). A single index test recorded a Liquid Limit of 54%, a Plastic Limit of 30% and a Plasticity Index of 24% indicating a silt of high plasticity with a low volume change potential. The sample plots just below the A-line.

Farrington and Barren Red Formation

9.2.5. Cohesive Residual bedrock

9.2.6. Bedrock of the Farrington and Barren Red Formation weathered to a residual clay material was encountered in SIX exploratory holes at depths of between 0.15m bgl (62.70m AOD) and 3.3m bgl (45.55m AOD) with a range in thickness of 0. 40m (BH03) to 2.00m (TP16). The material is generally described as soft to stiff grey, orangish brown slightly sandy, silty, slightly gravelly clay with gravel of fine to coarse mudstone lithorelicts.

Moisture Content and Atterberg Tests

9.2.7. Nine moisture content and Atterberg tests were undertaken on samples of the residual cohesive bedrock recording the following:

- Moisture Content - 15% to 38%;
- Liquid Limit - 37% to 64%;
- Plastic Limit - 19% to 23%;
- Plasticity Index - 15% to 41%.

9.2.8. The results indicate the material is a clay of intermediate to high plasticity.

9.2.9. 98% of fines are less than 495µ indicating the material of high volume change potential.

Particle Size Distribution

9.2.10. A single PSD test was undertaken on the cohesive residual bedrock from TP15 at 0.4m bgl recording 22% sand, 33% silt and 45% clay.

9.2.11. The sample tested was recorded to contain gravel of sub-angular and sub-rounded flint which may suggest the material is in fact Head deposit. Owing to the fines content it has been grouped with the residual cohesive bedrock.

Compaction

9.2.12. Four compaction tests were undertaken on samples of cohesive weathered bedrock recording the following:

- Maximum Dry Density – 1.56mg/m^3 – 1.91mg/m^3;

- Optimum Moisture Content – 15% - 23%.

9.2.13. The cohesive material is recorded to be variable in strength across the site indicating a potential undrained shear strength of 20kN/m^2 to 100kN/m^2.

Granular Residual Bedrock

9.2.14. The material was recorded as a sand and gravel between 0.15m bgl to 5.0m bgl indicating a more moderately weathered upper layer of the material. The gravel is generally described as a reddish brown silty sandy sub-angular and sub-rounded fine to coarse gravel and the sand as light reddish brown and grey mottled light grey slightly clayey gravelly fine to coarse.

Moisture Content and Atterberg Tests

9.2.15. A single test was undertaken on a sample of weathered mudstone which recorded a moisture content of 9%, a Liquid Limit of 42%, a Plastic Limit of 23% and a Plasticity Index of 19% indicating the material is a clay if intermediate plasticity. The material was logged as a clay but recorded as a gravel subsequent to testing indicating the high variability within the weathered portion of the bedrock within the site.

Particle Size Distribution

9.2.16. Thirteen PSD test was undertaken on the granular residual bedrock recording the following:

- Cobbles – 4% to 68%;
- Gravel – 26% to 70%;
- Sand – 1% to 45%
- Fines – 1% to 34%.

9.2.17. Tests indicated the material is a sand or gravel formed by the weathering of the sandstone layers within the Farrington Formation.

Compaction

9.2.18. One compaction test was undertaken on a sample of granular weathered bedrock recording the following:

- Maximum Dry Density – 1.84mg/m3;
- Optimum Moisture Content – 14%.

Sandstone

9.2.19. Sandstone was encountered in 23 exploratory holes at depths of between 0.25m bgl (65.10m AOD) in TP09 and 30m bgl (35.7m AOD to 21.80m AOD) in each of the boreholes with a range in thickness of 0.10 in TP14 and TP16 to 28.20m in BH05. The material was generally described as a weak to medium strong grey fine sandstone with randomly oriented fractures.

9.2.20. Eight Point Load Tests were undertaken on sample of the sandstone recording Is(50) values of 0.02MPa to 0.48Mpa which can be converted to uniaxial compressive strengths of 0.48MPa to 11.52MPa indicating a very weak to weak material.

Mudstone/siltstone

9.2.21. Mudstone was encountered in 5 exploratory holes at depths ranging between 2.00m bgl (54.85m AOD) to 12.55m bgl (39.25m AOD) with a range in thickness of 0.35m (BH03) to 8.1m (BH04). The

material is generally described as a medium strong to extremely weak thinly laminated, friable reddish brown or dark grey mudstone with closely spaced fractures locally trending to very stiff sandy silty clay. The fractures are rarely infilled with slightly gravelly silty clay.

9.2.22. Two Point Load Tests were undertaken on samples of siltstone recording Is(50) values of 0.04MPa to 0.28Mpa which can be converted to uniaxial compressive strengths of 0.92MPa to 6.44MPa indicating an very weak to weak material.

Coal

9.2.23. Coal was encountered in 2 exploratory holes: BH01 at 9.85m bgl (51.55m AOD) to 9.95m bgl (51.45m AOD) and BH04 between 9.7m bgl (49.05m AOD) and 9.75m bgl (49.00m AOD) and between 9.95m bgl (48.80m AOD) to 10.00m bgl (48.75m AOD). This suggests the productive coal seams within the area have thinned out considerably by the time they have reached beneath the site and were therefore not economically viable.

9.2.24. No further seams were encountered during the site investigation. The main seam adjacent to the site, the Rock Seam, is recorded to dip to the southwest and therefore historical excavations to exploit that seam ae unlikely to be present on-site. However, speculative excavations in the form of opencast workings and Bell Pits cannot be ruled out. The latest development plan indicates there are no proposed units towards the southern end of the site and therefore the risk of historical mining is considered low.

9.3. Buried Concrete

9.3.1. Six soil samples, comprising were subjected to pH and water soluble sulphate determinations. With reference to BRE Digest SD1 (2005 Ed), the results indicate a pH of between 6.7 and 7.7 and a water soluble sulphate concentration of less than 0.01g/l. BRE SD 1 indicates a DS-1 and AC-1.

9.3.2. Six soil samples were subjected to total sulphur and acid soluble sulphate content testing to allow an assessment to be made in relation to the potential thaumasite form of concrete attack. None of the oxidisable sulphides values calculated were in excess of 0.3%. Consequently, the results are not considered indicative of significant risk from this form of concrete attack.

9.4. Groundwater Conditions

9.4.1. Groundwater observations during the field and the subsequent monitoring are described in Section 7 and are summarised in Table 7.2. The groundwater at the site is variable across the site. The trial pits located in the north-eastern area of the site: TP14, TP15 and TP16 recorded groundwater between 1.6m bgl to 1.9m bgl coincident with the top of the unweathered sandstone of the Farringdon/Barren Red Formation.

9.4.2. Towards the south-western area groundwater was encountered at 0.8m bgl however no properties are proposed within this location. BH04 recorded a groundwater depth of 1.3m BGL.

10.0 GEOTECHNICAL HAZARDS

10.1.1. The anticipated geotechnical hazards associated with the site are summarised in Table 10.1.

Table 10.1: Summary of Geotechnical Hazards

Hazard	Description
Unknown bell pits / shallow mine workings	Considered unlikely as no productive outcrops located on site. Productive seams closest to the site outcrop and dip to the south of the site. Historical Bell pits may be present where shallow exploitation of coal seams has occurred. Locations of inadequately backfilled may be present towards the southern end of the site where coal outcrops. Subsidence and settlement related to the presence of historical coal mining remains a possibility. Three, thin coal seams between 0.05m and 0.1m were recorded during the ground investigation. The possibility of larger seams being present within the site cannot be ruled out and if encountered the potential for combustion should be considered.
Unknown ground conditions	Discreet areas of highly weathered bedrock reduced to a clay were encountered during the site investigation to variable depths. Additional unidentified areas of soft and compressible clays are likely to be present on site and may require excavation and replacement or ground reinforcement.
Poor founding material	The ground investigation highlighted areas of highly weathered bedrock reduced to a soft and compressible clay material. These are limited to discreet areas cross the site. Multi-story buildings such as apartment blocks will require piled foundations with piles passing through the overlying weathered material with sockets penetrating at least 2m into competent bedrock. Where houses are required to be built on filled areas, a stringent earthworks specification will be required and where necessary additional ground reinforcement incorporated. Additionally low strength made ground and head deposits are recorded in the north-eastern section of the site. CBR values are expected in areas of clays and made ground.
Slope stability	The site is located on a significant slope with a reduction of 25m OD from the northeast to the southwest and the bedrock beneath the site is dipping downslope. Areas where cuttings or steeper slopes are proposed or where levels are required to be raised will require careful assessment. Coal measure formations are inherently variable and softer, weaker layers can provide slip surfaces for overlying strata.
Retaining wall stability	Where retaining walls are required to enable the proposed gradient of the development these will require careful design to ensure the structure provides suitable support for required surcharge.
Shrink/Swell Clay	The site is underlain by clays with a Low volume change potential. Volume change of soil may result in the damage to services and structures on site especially in locations where vegetation is removed or planted. A requirement for deepened foundations may be required, particularly in the zone of influence of trees and heave protection measures may be required.
Shallow groundwater	Seepages were recorded in trial pits during the ground investigation and within some borehole locations. The depth of the groundwater need to be considered in terms of flooding and stability of excavations and cuttings.
Insufficient material suitable for fill	The bedrock of the Farrington and Barren Red Formation comprises significant amount of mudstone which may not be suitable for re-use on the site. At the time of writing this report a reasonable balance of cut/fill is estimated. However, if the excavated material is dominated by weak mudstones the material will require careful stockpiling and management of the stockpile is crucial to ensure the material does not deteriorate

Hazard	Description
Hard dig	Much of the site is underlain by competent bedrock at a shallow depth. During the site investigation several trial pits terminated on encountering solid bedrock and excavation may prove difficult in areas of cutting.
Former Structures	The foundation of the police station located at the north-eastern corner of the site may require the use f breaking apparatus.
Aggressive ground	The Coal Measures on which the site is located is known to contain pyrite and a suitable concrete Design Sulphate Class and Aggressive Chemical Environment for Concrete Class in accordance with BRE Special Digest 1 [Ref #].

11.0 REVISED CONCEPTUAL MODEL

11.1.1. Guidance for contaminated land advocates the assessment of risk by determining the presence of pollutant linkages and weighting the likelihood of harm occurring with the potential severity of that harm. The framework is set out in various publications by the DETR, Environment Agency, Institute for Environment and Health, NHBC and CIRIA.

11.1.2. Tables 4.2 and 4.3 indicate the potential contaminants, pollutant linkages and receptors that have been considered at the site. Following the investigation of these and Generic Quantitative Risk Assessment (for human health and controlled waters) a qualitative risk assessment is presented below in Table 11.1 – 11.5. For the purpose of this assessment, the descriptions of risk presented in Table 4.1 have been used which take into account the magnitude of the source contamination identified, likelihood of exposure via a pathway and significance of harm likely to result on the given receptor.

Table 11.1: Groundworkers (Assuming Basic PPE)*

Pathway	Risk	Comment
Ingestion of soil/dust	Very Low	Development or maintenance of the site may involve ground workers coming into contact with the underlying soils and water. Elevated concentrations of contaminants were not encountered within the soil or groundwater. Normal health and safety precautions associated with a site where potential contamination may exist (of the levels identified), will mitigate the general risk.
Inhalation of soil/dust	Very Low	
Dermal contact with soil/dust/water	Very Low	
Inhalation of vapour from soil/dust	Very Low	
Inhalation of vapour from groundwater	Very Low	
Migration of soil gases to confined spaces	Very Low	

* Separate assessments are required in relation to asbestos risk.

Table 11.2: End Users during Occupation

Pathway	Risk	Comment
Inhalation of dust	Very Low	Elevated contamination concentrations have not been identified across the site. Asbestos has not been detected across the site. A watching brief should be maintained throughout groundworks. There is a potential risk if previously unforeseen contamination is later found to be present.
Ingestion of soil/dust	Very Low	
Dermal contact with soil/dust/water	Very Low	
Consumption of vegetables/plants	Very Low	
Inhalation of vapour from soil/dust	Very Low	
Inhalation of vapour from groundwater	Very Low	
Migration of soil gases to confined spaces/structure	Very Low	
Movement of contaminants to engineered structures (e.g. water pipes)	Low	
Uptake by flora/fauna	Very Low	

Table 11.3: Controlled Waters

Pathway	Risk	Comment
Migration of water borne contaminants from site to surface waters	Very Low	Contamination was not encountered in the groundwater samples. A watching brief should be maintained throughout groundworks for any areas of unforeseen contamination.
Migration of water borne contamination from off site	Very Low	
Migration of contamination from surface and/or subsurface to groundwater	Very Low	

Table 11.4: Buildings

Pathway	Risk	Comment
Movement of contaminants to engineered structures (e.g. water pipes)	Low	Consideration will be required with respect to potable supply pipework due to the presence of detectable concentrations of hydrocarbons. Liaison with the water supply provider will be required to determine if remedial actions are required.
Migration and accumulation of flammable gases beneath the building footprint.	Very Low	Detectable concentrations of methane have not been encountered.

Table 11.5: Offsite Receptors

Pathway	Risk	Comment
Dermal contact with soil/dust/water	Very Low	Contamination was not encountered in soils or groundwater at the site. A watching brief should be maintained throughout groundworks for any areas of unforeseen contamination.
Inhalation/ingestion of dust	Very Low	
Inhalation of vapour from soil/dust	Very Low	
Inhalation of vapour from groundwater	Very Low	
Migration of soil gases to confined spaces/structure	Very Low	
Movement of contaminants to engineered structures (e.g. water pipes)	Very Low	

12.0 GEOTECHNICAL CONCLUSIONS AND RECOMMENDATIONS

12.1. Introduction

12.1.1. It is proposed to develop the site to enable the development of up to 260 residential dwellings.

12.1.2. Details of the structure and anticipated loadings were under development at the time of the writing of this report, which is based on a preliminary investigation. Further investigation will be required once proposals are fully developed and a detailed Geotechnical Design Report should be prepared. The primary purpose of this report is to identify risk, allow design development and inform cost estimates.

12.2. Key Considerations

12.2.1. The ground investigation has identified a number of potential geotechnical risks at the site, which relate to variability of the founding material and a potentially high groundwater table. These are summarised below and discussed in more detail in the following sections.

- Shallow Made Ground to depths of 0.4m bgl
- Soft to stiff clays to depths of 3.8m bgl
- Settlement prone soils
- Buried obstructions, such as old foundations and basements potentially at Sinnot House
- High volume change soils
- Soil desiccation
- Potential for mine workings and/or mineshafts including possible bell pits
- Large variations in site level and consequent need for earthworks and/or retaining walls
- Shallow groundwater level
- Negative skin friction acting on piles
- Large proposed structural loads

12.3. Historical mining

12.3.1. Close inspection of the ground surface following stripping of the site should be undertaken by a suitably qualified engineer in order to determine if evidence of coal mining is present on the site. The presence of historical coal mining is often inconclusive following ground investigation works and evidence of coal seams or associated workings may not be apparent until the upper layers of topsoil, superficial deposits and weathered bedrock is removed.

12.3.2. While considered unlikely, should bell pits or other shallow mine workings be encountered a detailed programme of open-hole drilling and grouting may be required.

12.4. Foundations

12.4.1. As described in Section 9.0, much of the site is underlain by sandstones and mudstones of the Farrington and Barren Red Formation including discreet areas of residual bedrock highly weathered to a soft to stiff clay material. It is considered for low rise buildings traditional strip or trench fill

foundations within the weathered bedrock will suffice. Where compressible materials are present due to their poor bearing capacity and settlement characteristics these will require excavation and replacement with lean mix concrete as the blinding concrete under foundations and as levelling course below footings.

12.4.2. Where cohesive soils are present, foundation depths should be determined in accordance with Chapter 4.2 of the NHBC Standards, based on a high volume change (shrink-swell) potential with due consideration of the proximity of existing or proposed trees. They should also be taken below any desiccated soils and 300mm below any live roots that may be encountered during excavation. Observations of such features as encountered during ground investigation are described in Section 9.0, however, the limitations of such data should be noted.

12.4.3. Where foundations depths in excess of 1.5m bgl are required heave protection measures in accordance with the NHBC Standards will be required.

12.4.4. Current proposals indicate housing will be founded as close as possible to the existing site topography to minimise the requirement for development platforms, retaining wall heights and fill.

12.4.5. Where shallow foundations are proposed within areas of fill a stringent earthworks specification will be required and additional reinforcement or even piling maybe required. Geotechnical recommendations for the type of foundation should be reassessed following confirmation of the final site masterplan.

12.5. Ground Improvement

12.5.1. It is not considered that ground improvement methods will be required owing to the shallow nature of the bedrock and suitable founding materials at shallow depths. Any soft cohesive material was recorded to a maximum depth of 1.5m and can be readily excavated.

12.6. Piles

12.6.1. Dependant on the final cut and fill profile of the site properties proposed to be constructed on deep fill may require pile foundations.

12.6.2. Four-storey apartments are proposed for the eastern area of the site which will require pile foundations through the deeper weathered material with sockets into the bedrock. The ground conditions are likely to be amenable to either CFA or bored piles, taking into account the following comments.

12.6.3. Bored piles would require casing to support the pile bore through any underlying granular strata.

12.6.4. There is the potential risk to bored pile instability from seepages in deeper strata which may require the use of a bentonite slurry or other suitable support fluid.

12.6.5. Any pile design will require consideration of the occurrence of negative skin friction where cohesive materials are present.

12.6.6. Table 12.1 below provides indicative total design resistances for individual piles, which require consideration against appropriately factored design actions as detailed in EC0 and EC7. Table 12.1 is based on 3m of cohesive material overlying competent bedrock. The cohesive material is assumed to make no contribution to resistance and negative skin friction is ignored as the pile is anticipated to be founded on or socketed into the bedrock.

TABLE 12.1: Indicative Design Resistances for Continuous Flight Auger (CFA) Piles

Pile diameter	Total Compressive Design Resistances* (kN)		
	Pile Toe Depth m bgl		
	5m	7.5m	10m
300mm	100	200	315
450mm	160	320	490
600mm	230	450	680

Values in italics relate to tensile capacity.
* To be used in conjunction with ULS design actions for Combination 2 of Design Approach 1

12.6.7. The design of piled foundations will require further assessment once the ground profile has been finalised. The advice of reputable piling specialists, experienced in the ground conditions considered here, should be sought. They should be responsible for the selection of appropriate piling equipment and the final design of the piles.

12.6.8. The adoption of maintained load tests in accordance with EC7 would enable increased capacities or shorter piles to be adopted. The piling specialist will adopt suitable parameters, which should be verified by an experienced geotechnical engineer.

12.7. Floor Slabs

12.7.1. Depending on the final profile of the site suspended floor slabs will be required if proposed levels require 600mm or more of fill material.

12.7.2. Heave protection measures as per current NHBC standards will be required where cohesive materials are located within the foundation depths.

12.7.3. In relation to piled construction, void formers will be required below all ground beams and pile caps in accordance with NHBC standards.

12.8. Road Pavements

12.8.1. Assuming formation soils comprise a variety of cohesive and granular materials an equilibrium CBR value of 1% is recommended. Confirmatory testing of the excavation should be undertaken to confirm an accurate CBR value for the soils.

12.8.2. It is anticipated that road pavement may be constructed on fill. It is recommended that such fill is placed and compacted in accordance with a suitable specification based on the Specification for Highway Works. Pavement surfaces should be constructed in flexible materials such as bituminous compounds or block paving. The CBR value to be adopted would depend on the nature of the fill specification adopted and the as built quality of the fill, however, assuming site won soils are used and that the soils are suitably compacted, it is recommended that CBR value of 15% is adopted. Additional testing of the fill just prior to road construction is recommended, so as to confirm matters.

12.8.3. Highway pavements should be designed to at least 450mm thickness to prevent the possibility of damage from frost action.

12.9. Buried Concrete

12.9.1. In the consideration of sulphate attack on buried concrete, reference has been made to BRE Special Digest 1 which classifies the site as a greenfield site with a mobile groundwater conditions. Additionally, as the coal measures can be pyrite bearing, it has also been necessary to assess the potential for the thaumasite form of attack. The results of the concrete classification tests received have indicated a DS-1 classification, together with the pH values indicates that an ACEC AC-1 should be adopted.

12.10. Drainage

12.10.1. The soakaway test results indicate that the site is not suitable for soakaway drainage. Any drainage should be designed in accordance with NHBC to protect against the potential for ground movement.

12.11. Excavations

12.11.1. As described above, the groundwater depth is variable across the site. The trial pits located in the north-eastern area of the site: TP14, TP15 and TP16 recorded groundwater between 1.6m bgl to 1.9m bgl coincident with the top of the unweathered sandstone of the Farringdon/Barren Red Formation. Dewatering and shoring measures may be required for excavations at this location.

12.11.2. Towards the south-western area groundwater was encountered at 0.8m bgl however no properties are proposed within this location. BH04 recorded a groundwater depth of 1.3m bgl thus it is considered that dewatering and shoring measures will be required for excavations located within lower elevations within the proposed development.

12.11.3. Trial pits remained stable during the ground investigation. However, stability in excavation faces in Made Ground, highly weathered residual bedrock and sand and gravels cannot be relied upon and allowance should be made for battering faces back to a safe angle of repose, or providing shuttering. Support or battering of the excavation faces to a safe angle of repose will be required for all excavations where man entry is necessary, the nature and extent of which will need to be evaluated under CDM regulations.

12.11.4. Excavated cohesive material may be re-useable on site for landscaping purposes or as earthwork fill.

12.11.5. At the time of writing this report there is an anticipated balance in cut/fill volumes. The shallow bedrock may prove difficult to excavate as several trial pits were terminated at shallow depths due to refusal. Point Load tests indicate the bedrock is of very weak to weak material and therefore excavation is anticipated to be achievable however based on the ground investigation additional breaking equipment may be required.

12.11.6. Excavated bedrock may be processed for re-use on site, however, this material will require testing, classification, placement and compaction in strict accordance with the UK Specification for Highways Works (SHW).

12.11.7. In areas of road pavements and hard standing, relic subterranean structures, if encountered' should be broken down to around 1.0m below finished site level to minimise the risk of differential settlement due to the presence of hard spots.

12.11.8. In areas of cutting consideration must be given to the shallow groundwater and suitable drainage measures put in place. While only thin coal seams of 0.05m were encountered during the site investigation works consideration should be given to the occurrence of exposing these seams and the possibility of their combustion on contact with air.

12.12. Retaining Walls

12.12.1. Currently the proposed development requires a degree of cut and fill that will require the provision of retaining walls to achieve the required profile, which follows the exiting topography. Any retaining structure will require design by a specialist engineer. The proximity to building to the retaining wall will require careful consideration.

12.12.2. Any requirements for retaining walls would need to be assessed upon confirmation of a final development profile.

12.13. General Construction Advice

12.13.1. It should be possible to use conventional excavators to form excavations in the soils encountered during the investigation. However, hard surfacing, old foundations, relict basement construction and the like, if present, may require the use of breaking apparatus. Shallow bedrock was encountered in trial pits TP01, TP03, TP04, TP07 and TP08 between 0.5m bgl and 0.7m bgl leading to excavator refusal at approximately 1.0m bgl.

12.13.2. For any load bearing formations, careful inspection should be undertaken to ensure placement in competent natural strata unless ground treatment has been carried out and properly validated. Any soft spots identified should be excavated replaced with lean mix concrete. Concrete should be placed as soon as possible following excavation to avoid softening of the ground. A similar recommendation is also made for road pavement formations, although compacted granular fill could be used instead of concrete.

12.13.3. Any relic foundations or other subterranean structures beneath the footprint of the proposed buildings should be fully grubbed out. Such excavations should be surveyed and backfilled with an acceptable granular fill, placed and compacted to an engineering specification. The same recommendations are made for excavations that may be required to remove soil contamination.

12.13.4. In areas of road pavements and hard standing, relic subterranean structures, for example in the north eastern corner of the site, should be broken down to around 1m below finished site level to minimise the risk of differential settlement due to the presence of hard spots. In soft landscaped areas it may be possible to limit such operations to 0.50m bgl.

12.14. Recommendations for Further Work

12.14.1. The preceding sections have attempted to provide recommendations regarding the information acquired during the recent ground investigation and are therefore based on the inherently limited information at the location of each exploratory hole. While the site is located within a major coal mining area, the boreholes undertaken during the ground investigation works only encountered thin coal seams which had fined out to 0.05m to 0.1m. The rock vein, one of the most productive seams within the area is indicated to outcrop south of the site with a dip towards the south or south-west and is therefore not considered to present a risk to the development. The Salridge seam is indicated to outcrop north of the site and the dip of the strata indicated on the published information suggests the seam should occur at shallow depth beneath the site however the only seams recorded were non-viable and are not anticipated to present a risk.

12.14.2. Of prime concern at this location was the presence of shallow mine workings in the form of historical bell pit excavations or shallow opencast working especially in relation to the coal seam present at the southern boundary of the site. No developments are proposed within this area, however,

significant excavations are proposed in the southern area for drainage provision. While the risks are considered to be low, the potential for unrecorded shallow workings within this area cannot be discounted. Once the top soil in this area has been stripped, the site should be inspected by a suitably qualified engineer to determine the presence or otherwise of potential historical workings.

12.14.3. Based on the recent ground investigation ground improvement is not considered necessary, however, additional investigation works may encounter locations within the site where some form of ground treatment may be considered.

13.0 ENVIRONMENTAL CONCLUSIONS AND RECOMMENDATIONS

13.1. Summary of Risk

13.1.1. The site investigation commissioned by CampbellReith incorporated contamination testing of soil and monitoring of groundwater and ground gas across the site. In addition, available Desk Study information has been consulted.

13.1.2. The site is considered to lie in area of Medium environmental sensitivity with respect to Hydrogeology and a High environmental sensitivity with respect to Hydrology. The proposed residential with gardens development is considered to be of High end user sensitivity. The site is considered to present a Low risk in relation to contamination issues.

13.2. Summary of Contamination

13.2.1. Desk study and subsequent site investigation and chemical analysis has identified the following key contamination issues at the site:

- Soils: No significantly elevated contaminant concentrations and asbestos have been encountered.
- Groundwater: No significantly elevated contaminant concentrations have been encountered in groundwater in both the 2020 and 2022 ground investigations
- Ground gas: The site is considered to be a CIRIA Characteristic Situation 1 and as such, gas protection measures are not considered to be necessary. In addition, vapour protection measures are also not required.

13.2.2. Whilst no remediation measures are considered necessary to permit the development, a number of actions will be required to control the works and verify material suitability etc these are described below. These relate to:

- Verification Control Documents
- Waste Management

13.3. Outline Remedial Recommendations

13.3.1. The following section details outline remedial/verification recommendations. These should be considered in light of the recommendations for any further works presented above which could lead to their modification. Detailed remedial or verification testing should be finalised in a Groundworks/ Remediation Specification.

13.3.2. A watching brief should be maintained throughout the groundworks in order to identify any previously undetected areas of contamination; such as asbestos containing materials and/or stained/odorous soils. These should be assessed by an Environmental Consultant if identified.

End Users

13.3.3. The assessment generally identified a VERY LOW RISK for site end users associated with the absence of significant soil contaminant concentrations.

13.3.4. In addition, any excavations should be backfilled with soils, which are suitable for use and in accordance with the appropriate Remediation and/or Groundworks Specification compiled by the Engineer.

13.3.5. Imported materials for soft landscaped areas will require provision for testing in accordance with the Remediation Specification and compliance with an agreed set of limiting values will be required. Records as detailed within the Remediation Specification and/or Groundworks Specification should be maintained to certify the source, chemical suitability and appropriate placement of the soils.

Groundworkers

13.3.6. The qualitative assessment identified a potentially VERY LOW – LOW RISK to groundworkers who may come into contact with contaminated soils and waters.

13.3.7. The Contractor should prepare risk assessments and method statements in view of the identified and foreseeable ground conditions and include these within the Health and Safety Plan: for example, these should consider worker protection from skin contact, ingestion and inhalation of contaminants, asbestos in soils and ground gas. In order to achieve satisfactory control, CampbellReith recommend that Health and Safety provisions in accordance with HSE Publication HS(G) 66 and CIRIA Report 132 are considered. The Contractor must also control matters such as any contracted CDM responsibilities.

13.3.8. In relation to presence of asbestos in soils, the Contractor should formulate their working arrangements in view of the requirements of the Control of Asbestos Regulations (2012) and the associated ACoP (L143). Additional interpretation on the application of these regulations is presented in publications prepared by CL:AIRE and the Joint Industry Working Group (CAR-SOIL™ Control of Asbestos Regulations 2012, Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials, 2016; and the associated JIWG decision support tool, 2017). Additional guidance is provided in CIRIA C765, Asbestos in Soil and Made Ground Good Practice Site Guide, 2017.

Controlled Waters

13.3.9. The qualitative assessment identified a potentially VERY LOW RISK for groundwater.

13.3.10. Taking into account the above information remedial works are not required for controlled waters. Notwithstanding this, a watching brief should be maintained across the site during groundworks, for any areas of unidentified contamination.

Ground Gas/Vapours

13.3.11. The ground gas risk assessment indicates that the site can be classified as a CIRIA Characteristic Situation 1 and gas protection measures are not required.

Services

13.3.12. The presence of detectable hydrocarbon concentrations in the soil indicates a possible need for protection of public water supply pipework, such as the use of organic resistant pipework. The infrastructure designer should assess requirements for pipework with respect to soil contamination and consult statutory utility companies and relevant guidance as necessary. Guidance on this topic is presented in UKWIR Report 'Publication UKWIR Report Ref 10/WM/03/21: Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites - Final Project Report, as amended by the Contaminated Land Assessment Guidance (Water UK, January 2014) .

13.4. Remediation and Verification Control Documents

13.4.1. Following on from the recommendations made herein, in order to control the environmental works on site and facilitate the collection of records required for the Verification Report, a Groundworks Specification will be required. The Specification should detail necessary requirement for inspections/ record keeping/ actions for unforeseen contamination/ detail the requirements for the control of imported material, its suitability testing and waste management.

13.4.2. The Specification will require submission to the Local Authority for review and approval as part of the planning process, to fulfil the requirements of the anticipated land quality planning condition. Failure to submit the required documentation could result in refusal to discharge associated Land Quality Planning Conditions, and discussions should be held with the relevant Officer at an early stage to ensure all necessary information is obtained and collated for their review and approval. Additional discussions may be required with the NHBC and/or Building Control, such matters are not detailed herein. Once approved it will be the Contractor's obligation to fulfil the agreed requirements of the Specification.

13.4.3. Should the groundworks encounter fuel tanks, removal of any such features is required in accordance with an appropriate tank removal specification and Contractor's method statements, which meet the requirements of the appropriate Environment Agency Pollution Prevention Guidelines (PPG).

13.5. Waste Management

13.5.1. A hazardous properties assessment of waste soils has not been undertaken as part of this report and is recommended The soil results can, however, be used by the Contractor as a basis for waste soil classification and disposal purposes; however, additional testing may be required, particularly if non-representative soils are uncovered such as those that are stained, odorous or containing asbestos.

13.5.2. All waste related activities must be undertaken in accordance with the Waste Management and Landfill Regulations. Any proposed reuse of materials must be in accordance with the Waste (England and Wales) Regulations 2011 (as amended). With respect to waste soils disposal, as a minimum, the following information should be collected and retained by the Contractor for subsequent validation:

- source and origin of the waste;
- information on the process producing the waste;
- European Waste Catalogue code and characteristics of material;
- for hazardous waste, definition of the relevant properties according to the Hazardous Waste Directive (Annex III 91/689/EC);
- confirmation that waste is not prohibited waste;
- appearance of the waste;
- landfill class; and,
- Duty of Care records including full and completed chain of custody documentation.

13.5.3. The final waste classification is the responsibility of the Contractor and should be determined in conjunction with the receiving landfill and in liaison with the Environment Agency (and their technical guidance). It is noted that, depending on the landfill selected, additional soils testing information

and independent verification of the materials of the materials being received by the landfill may be required.

13.5.4. As the correct classification of waste is likely to have a significant impact on the redevelopment budget, the waste classification should be reviewed independently by a consultant at an early stage in the project management stage. In addition, contractors should be asked to confirm that their tenders consider the full requirements of the Landfill Directive and associated waste legislation. This is to ensure waste is correctly classified and costed at the inception of the project.

13.5.5. The Landfill Directive states that all hazardous and non-hazardous waste requires treatment prior to disposal to landfill. Treatment must provide a 'three – point step'. As such, provision for treating (including physical separation) should be made for all arisings that are likely to be classified as hazardous or non-hazardous so that each of the above three requirements are met.

13.5.6. A separate assessment should be made for the rate of Landfill Tax (where applicable) in accordance with HMRC Excise Notice LFT1.

TECHNICAL REFERENCES

Reference*	Reference Title	Type
[2]	British Geological Survey (BGS) Sheet 264, Bristol, 1:50,000 scale, 2004 Series	Map
[3]	British Geological Survey (BGS) Geology of the Bristol district : memoir for 1:63360 geological special sheet (England & Wales), 1993	Map
[4]	Zetica UXO Risk Maps (https://zeticauxo.com/downloads-and-resources/risk-maps/)	Website
[5]	EOD Contracts Ltd Explosive Ordnance Desktop Study For Brislington Meadows, Bristol (Ref. 19481, Dated 19th September 2019)	Report
[6]	Brimstone Site Investigation Non-intrusive UXO Survey Report (ref. 20210421-NIREP-CAMP11, Dated 29th April 2021)	Report
[7]	Brimstone Site Investigation Target Investigation Report (ref. 202111206-TIREP-CAMP13, Dated 6th December 2021)	Report
[12]	*Envirocheck Report (ref. 70063012, Dated: August 2019)	Report

*Contained within WSP Technical Due Diligence Report

ENVIRONMENTAL RISK ASSESSMENT SUPPORTING INFORMATION

Soil Screening Values

The Environment Agency has published non statutory technical guidance for Regulators and their advisors to assess the chronic risk posed to human health from land contamination, known as the Contaminated Land Exposure Assessment (CLEA) Framework.

The CLEA Framework documents and associated risk assessment model are subject to ongoing technical review. In July 2008 guidance documents CLR7 to 10, which previously underpinned the CLEA Framework, were withdrawn. In January 2009 the Environment Agency published CLEA V1.04 risk assessment software and associated guidance documents[4] as a replacement to the previous CLEA UK Beta Version and documents CLR 7 to 10. Further revisions were made in September 2009 to CLEA V1.05 and October 2009 to CLEA 1.06 risk assessment software.

Soil Guideline Values (SGVs) were produced by Defra/EA and Generic Assessment Criteria (GACs) were produced by CampbellReith and others. These were based on the CLEA model and supporting guidance (SR2 and SR3) and where based on a minimal/tolerable level of risk.

In December 2014 DEFRA released final versions of the C4SLs (Category 4 Screening Levels) for 6 No. contaminants (As, benzene, BaP, Cd, Cr VI and Pb) together with a Policy Companion Document and an Erratum. These represent contaminant soil concentrations which present an acceptable (Low) level of risk, within the context of Part 2A, i.e. they are representative of Category 4 sites. In the Contaminated Land Statutory Guidance (April 2012), sites under Part 2A assessments are categorised 1 - 4, with Category 1 being definitely Part 2A and Category 4 definitely not Part 2A ('where there is no risk or the level of risk posed is low').

The C4SLs were produced using the CLEA model and follow the general approach of SR3, although, changes were made to exposure parameters and to the toxicological basis of the assessments. The C4SLs are based on a low level of toxicological concern (LLTC) and are, by definition, less conservative than Health Criteria Values (HCVs) which are the basis for assessments defined in SR2 and used in the generation of SGVs and GACs. They are, therefore, indicative of a low level of risk.

Since their release, DEFRA have confirmed that C4SLs can be used in the planning regime and DCLG (Department for Communities and Local Government) amended Planning Practice Guidance (PPG) on Land Affected by Contamination (12 June 2014)[5] which stated that C4SLs provide a simple test for deciding when land is suitable for use and definitely not contaminated land'. On 03 September 2014 the Secretary for the Environment, Lord de Mauley, issued a letter (attached) to all Local Authorities which references DCLG's PPG and confirms that C4SLs could be used in planning and provide a simple test for establishing when sites are suitable for use.

LQM/CIEH issued S4ULs in December 2014 for 89 contaminants (metals, BTEX, banded TPH, speciated PAH, chlorinated solvents, phenols, chlorophenols, chlorobenzenes, pesticides and a number of miscellaneous others). The S4ULs have generally adopted the revisions to the exposure modelling that were developed in the production of the C4SLs. Critically, however, they are based on HCVs to produce concentrations which are indicative of a minimal/tolerable level of risk.

S4ULs are therefore used as the preliminary stage of soil assessments since they are indicative of minimal/tolerable level of risk. If these are exceeded then the C4SLs are used (if available) to determine if the risk could be described as low.

Where CLEA compliant S4ULs or C4SLs are not available reference is made to Generic Assessment Criteria (GAC) derived using the CLEA UK model (beta version). These are currently used for cyanide. Where referred to, the non-compliant standing of these values is considered.

[4] Environment Agency Report Ref: SC050021/SR2 - *Human Health Toxicological Assessment of Contaminants in Soil.* January 2009. Environment Agency Report Ref: SC050021/SR3 – *Updated background to the CLEA model.* January 2009.

[5] http://planningguidance.planningportal.gov.uk/blog/guidance/land-affected-by-contamination/land-affected-by-contamination-guidance/

Selection of Appropriate [Tier 2] Soil Screening Values

The CLEA model is based upon defined exposure scenarios and six generic land uses have been established for the C4SLs and S4ULs. These set out a discrete set of circumstances where exposure may occur, including a source, the pathways, and the exposed population.

The three generic land use scenarios used in the development of SGVs are:

- commercial/Industrial;
- allotments;
- residential with plant uptake,
- residential without plant uptake,
- public open space (residential)
- public open space (parks)

It is noted that the CLEA screening values are generic and not always applicable. Where the CLEA conceptual model is not appropriate it will be necessary to develop site specific Detailed Quantitative Risk Assessment screening values as a further stage of assessment.

It is noted that the CLEA model does not consider risks from contaminated waters beneath the site to human health and the model also assumes that no free product is present. Should such conditions exist at the subject site the requirement for application of an alternative risk assessment model should be assessed. Alternatively, construction workers are potentially exposed to acute risk and therefore require separate consideration.

Statistical Analysis of Soil Analytical Results

Statistical analysis of soil based analytical results has been undertaken in accordance with CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration (May 2008). The use of the Mean Value Test and Maximum Value Test is still considered appropriate for site assessments. Althoµg/lh the guidance advocates use of the one - sample t test, this is a variation of the mean value test and establishes the confidence level at which the assessor can determine whether a particular screening level has/has not been succeeded. The mean value test used herein is set at the 95th percentile confidence limit in order to be risk conservative.

The Maximum Value Test is a statistical tool that is used to identify outlier values from a numerical distribution of results for a given determinant. These outlier values can be excluded and considered separately, and the remaining values are then used to calculate upper bound 95th percentile values ($95^{\%ile}$) (Mean Value Test) for comparison with the screening values.

The results are reviewed prior to any statistical analysis in order to determine if zoning of the soils is apparent and hence whether the site requires to be divided into averaging areas. Additional tables are presented where appropriate to reflect distinct ground characteristics relevant to the conceptual model.

Water Screening Values

This assessment considers potential risks to controlled waters (groundwater and surface waters) in relation to risks from any historical contamination. The most stringent test is that defined for Contaminated Land under Part 2A of the Environmental Protection Act, 1990. However, it should be recognised that a wider evaluation of risk is considered within the planning regime and CLR 11.

The Environment Agency has a wider policy agenda for the protection of controlled waters that will impinge upon judgements in relation to land contamination issues. This includes those for the Water Framework Directive and Groundwater Directive and wider legislation for both groundwater, surface water and associated elements (such as fisheries)[6].

The results of water analysis have been compared to screening values selected to assess the potential risk to the identified controlled water receptors in the Conceptual Model. The specific standards utilised for this purpose are considered in the assessment table footnotes and typically comprise: Environmental Quality Standards for the protection of aquatic life; Surface Water Standards; EC, UK and WHO Drinking Water Standards; or Background water quality (where no applicable standard exists).

The initial assessment considers the sensitivity of the receptor in the selection of the screening value. Advice for this purpose has been obtained principally from Environment Agency Technical Advice to Third Parties on Pollution of Controlled Waters for Part 2A of the Environmental Protection Act 1990, No 07/02, EA, 2002 (INFO-RA2-3e), as informed by the EA's GP3.

Where a viable pollutant linkage is considered to be present and the screening criteria exceeded, a Qualitative Risk Assessment is presented with associated recommendations. Depending on the specific objectives, policy and practice of the Environment Agency, discussion of water screening values may be subsequently required.

Definitions of Consequence, Probability and Risk

The following classification has been taken from Guidance for the Safe Development of Housing on Land Affected by Contamination R&D66: 2008 Volume 1 (Environment Agency, NHBC and CIEH.

The key to the classification is that the designation of risk is based upon the consideration of both:

a) the magnitude of the potential consequence (i.e. severity).

[takes into account both the potential severity of the hazard and the sensitivity of the receptor]

b) the magnitude of probability (i.e. likelihood).
[takes into account both the presence of the hazard and receptor and the integrity of the pathway]

[6] Refer to Environment Agency Publications for Groundwater Protection Policy and Practice (GP3)

Classification of Consequence

Classification	Definition	Examples
Severe	Highly elevated concentrations likely to result in "significant harm" to human health as defined by the EPA 1990, Part 2A, if exposure occurs. Equivalent to EA Category 1 pollution incident including persistent and/or extensive effects on water quality; leading to closure of a potable abstraction point; major impact on amenity value or major damage to agriculture or commerce. Major damage to aquatic or other ecosystems, which is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population. Catastrophic damage to crops, buildings or property.	Significant harm to humans is defined in circular 01.2006 as death, disease*, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Major fish kill in surface water from large spillage of contaminants from site. Highly elevated concentrations of List I and II substances present in groundwater close to small potable abstraction (high sensitivity). Explosion, causing building collapse (can also equate to immediate human health risk if buildings are occupied).
Medium	Elevated concentrations which could result in "significant harm" to human health as defined by the EPA 1990, Part 2A if exposure occurs. Equivalent to EA Category 2 pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce. Significant damage to aquatic or other ecosystems, which may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. Significant damage to crops, buildings or property.	Significant harm to humans is defined in circular 01/2006 as death, disease*, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Damage to building rendering it unsafe to occupy e.g. foundation damage resulting in instability. Ingress of contaminants throµg/lh plastic potable water pipes.
Mild	Exposure to human health unlikely to lead to "significant harm". Equivalent to EA Category 3 pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture or commerce. Minor or short lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population.	Exposure could lead to slight short-term effects (e.g. mild skin rash). Surface spalling of concrete.

Classification	Definition	Examples
	Minor damage to crops, buildings or property.	
Minor	No measurable effect on humans. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects of damage to buildings, structures and services.	The loss of plants in a landscaping scheme. Discoloration of concrete.

Classification of Probability

Classification	Definition	Examples
High likelihood	There is pollutant linkage and an event would appear very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.	*a) Elevated concentrations of toxic contaminants are present in soils in the top 0.5m in a residential garden.* *b) Ground/groundwater contamination could be present from chemical works, containing a number of USTs, having been in operation on the same site for over 50 years.*
Likely	There is pollutant linkage and all the elements are present and in the right place which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.	*a) Elevated concentrations of toxic contaminants are present in soils at depths of 0.5-1.0m in a residential garden, or the top 0.5m in public open space.* *b) Ground/groundwater contamination could be present from an industrial site containing a UST present between 1970 and 1990. The tank is known to be single skin. There is no evidence of leakage althoμg/lh there are no records of integrity tests.*
Low likelihood	There is pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a long period such an event would take place, and is less likely in the shorter term.	*a) Elevated concentrations of toxic contaminants are present in soils at depths >1m in a residential garden, or 0.5-1.0m in public open space.* *b) Ground/groundwater contamination could be present on a light industrial unit constructed in the 1990s containing a UST in operation over the last 10 years – the tank is double skinned but there is no integrity testing or evidence of leakage.*
Unlikely	There is pollutant linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.	*a) Elevated concentrations of toxic contaminants are present below hardstanding.* *b) Light industrial units <10 yrs old containing a double-skinned UST with*

Classification	Definition	Examples
		annual integrity testing results available.

Note: A pollution linkage must first be established before probability is classified. If there is no pollution linkage then there is no potential risk. If there is no pollution linkage then there is no need to apply tests for probability and consequence.

For example if there is surface contamination and a principal aquifer is present at depth, but this principal aquifer is overlain by an aquiclude of significant thickness then there is no pollution linkage and the risks to the principal aquifer are not assessed. The report should identify both the source and the receptor but state that because there is no linkage there are no potential risks.

Description of the classified risks

Very high risk
There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without remediation action OR there is evidence that severe harm to a designated receptor is already occurring. Realisation of that risk is likely to present a substantial liability to be site owner/or occupier. Investigation is required as a matter of urgency and remediation works likely to follow in the short-term.

High risk
Harm is likely to arise to a designated receptor from an identified hazard at the site without remediation action. Realisation of the risk is likely to present a substantial liability to the site owner/or occupier. Investigation is required as a matter of urgency to clarify the risk. Remediation works may be necessary in the short-term and are likely over the longer term.

Moderate risk
It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely, that the harm would be relatively mild. Further investigative work is normally required to clarify the risk and to determine the potential liability to site owner/occupier. Some remediation works may be required in the longer term.

Low risk
It is possible that harm could arise to a designated receptor from identified hazard, but it is likely at worst, that this harm if realised would normally be mild. It is unlikely that the site owner/or occupier would face substantial liabilities from such a risk. Further investigative work (which is likely to be limited) to clarify the risk may be required. Any subsequent remediation works are likely to be relatively limited.

Very low risk
It is a low possibility that harm could arise to a designated receptor, but it is likely at worst, that the harm if realised would normally be mild or minor.

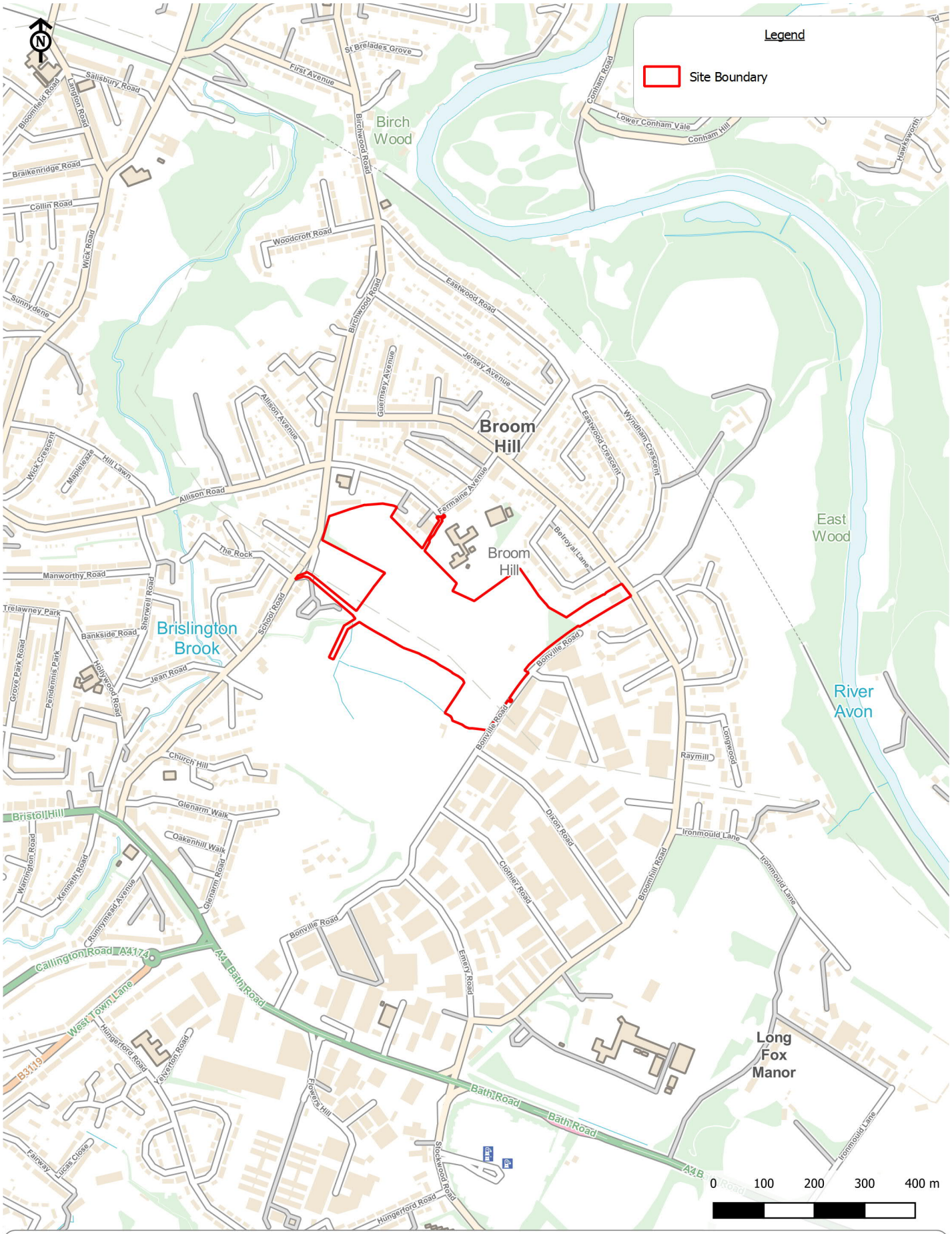
No potential risk
There is no potential risk if no pollution linkage has been established.

LIMITATIONS

Environmental & Geotechnical Interpretative Reports

1. This report provides available factual data for the site obtained only from the sources described in the text and related to the site on the basis of the location information provided by the client.
2. Where any data or information supplied by the client or other external source, including that from previous studies, has been used, it has been assumed that the information is correct. No responsibility can be accepted by CampbellReith for inaccuracies within this data or information. In relation to historic maps the accuracy of maps cannot be guaranteed and it should be recognized that different conditions on site may have existed between and subsequent to the various map surveys.
3. This report is limited to those aspects of historical land use and enquiries related to environmental matters reported on and no liability is accepted for any other aspects. The opinions expressed cannot be absolute due to the limit of time and resources implicit within the agreed brief and the possibility of unrecorded previous uses of the site and adjacent land.
4. The material encountered and samples obtained during on-site investigations represent only a small proportion of the materials present on the site. There may be other conditions prevailing at the site which have not been revealed and which have therefore not been taken into account in this report. These risks can be minimised and reduced by additional investigations. If significant variations become evident, additional specialist advice should be soµg/lht to assess the implications of these few findings.
5. The generalised soil conditions described in the text are intended to convey trends in subsurface conditions. The boundaries between strata are approximate and have been developed on interpretations of the exploration locations and samples collected.
6. Water level and gas readings have been taken at times and under conditions stated on the exploration logs. It must be noted that fluctuations in the level of groundwater or gas may occur due to a variety of factors which may differ from those prevailing at the time the measurements were taken.
7. Please note that CampbellReith cannot accept any liability for observations or opinions expressed regarding the absence or presence of asbestos or on any product or waste that may contain asbestos. We recommend that an asbestos specialist, with appropriate professional indemnity insurance, is employed directly by the client in every case where asbestos may be present on the site or within the buildings or installations. Any comments made in this report with respect to asbestos, or asbestos containing materials, are only included to assist the client with the initial appraisal of the project and should not be relied upon in any way.
8. The findings and opinions expressed are relevant to those dates of the reported site work and should not be relied upon to represent conditions at substantially later dates.
9. This report is produced solely for the benefit of the client, and no liability is accepted for any reliance placed upon it by any other party unless specifically agreed in writing.

Appendix A: Figures



Brislington Meadows, Bristol

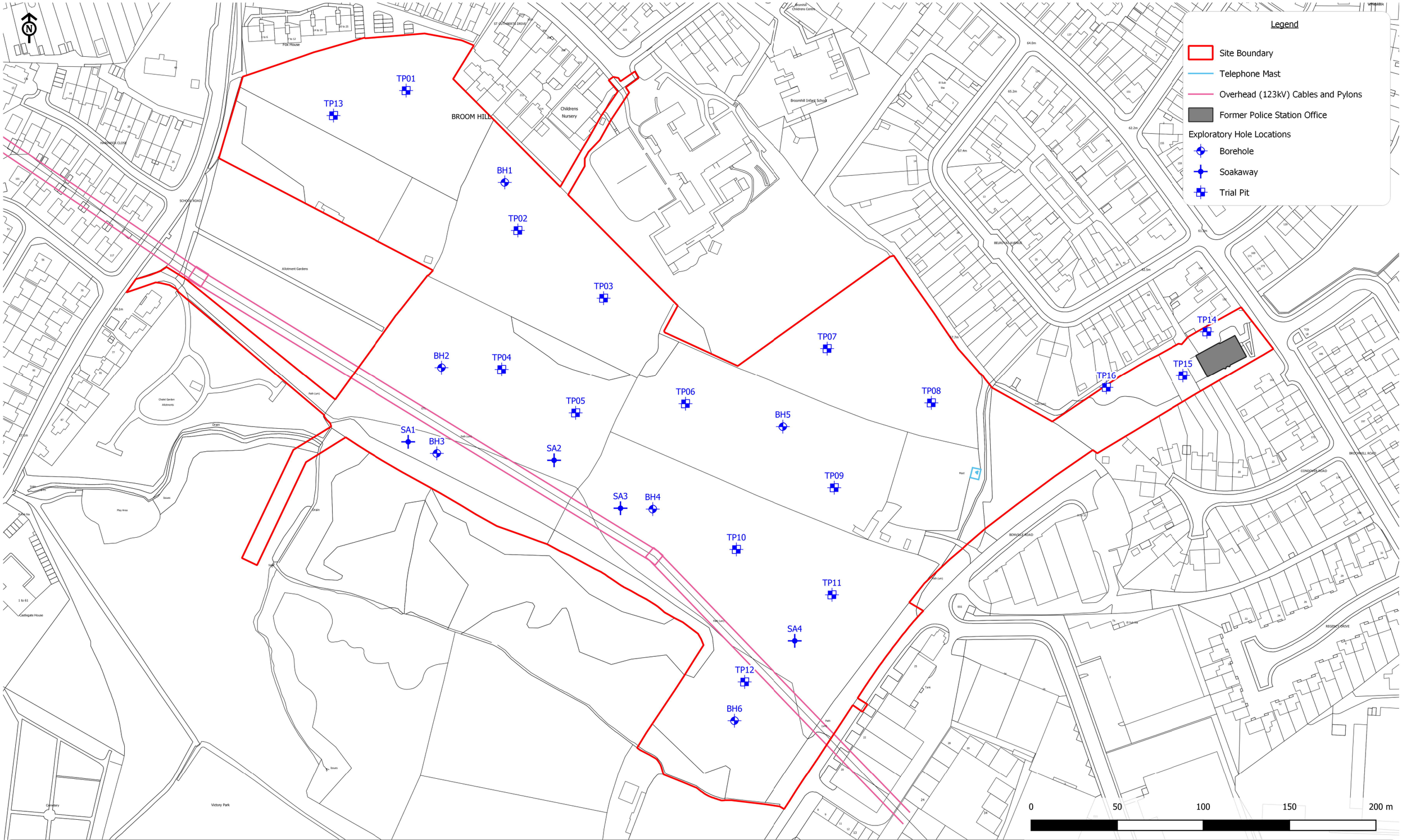
Client: Bristol City Council

Figure 1:
Site Location Plan

Scale: 1:10000@A4

Job Number: 13492
Drawn by - Checked by: RP - BR
Drg No - Status/Revision: 13492-CRH-XX-XX-FG-G-7026 - P2
File location: N:\13250 - 13499\13492 B - Brislington Meadows\Project_Workspaces\LQS (pdf in Outputs)
Date (Revision History): 16/03/2022 (P1, First Issue, 09/02/22, RP; P2, Boundary Update, 16/03/22, RP)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☐ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☐ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☒ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com



Brislington Meadows, Bristol

Client: Homes England

Figure 2:
Site Layout and Exploratory Hole Locations

Scale: 1:2000@A3

Job Number: 13492
Drawn by - Checked by: RP - BR
Drg No - Status/Revision: 13492-CRH-XX-XX-FG-G-7027 - P2
File location: N:\13250 - 13499\13492 B - Brislington Meadows\Project_Workspaces\LQS (pdf in Outputs)
Date (Revision History): 16/03/2022 (P1, First Issue, 09/02/22, RP; P2, Boundary Update, 16/03/22, RP)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☐ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☒ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com

Brislington Meadows, Bristol

Client: Homes England

Figure 3:
Proposed Development and Exploratory Hole Locations

Scale:	1:2000@A3
CampbellReith OS Copyright:	© Crown copyright. All rights reserved. Licence number 100020027
LDA Illustrative Masterplan, drg no 7456_039ZB (Mar 2022)	
Job Number:	13492
Drawn by - Checked by:	RP - BR
Drg No - Status/Revision:	13492-CRH-XX-XX-FG-G-7028 - P3
File location:	N:\13250 - 13499\13492 B - Brislington Meadows\Project_Workspaces\LQS (pdf in Outputs)
Date (Revision History):	16/03/2022 (P1, First Issue, 09/02/22, RP; P2, Updated Proposed Development, 21/02/22, RP; P3, Updated Proposed Development, 16/03/22, RP)

CampbellReith
consulting engineers
LONDON 020 7340 1700 ☐ ☐ MANCHESTER 0161 819 3060
REDHILL 01737 784 500 ☒ ☐ BIRMINGHAM 01675 467 484
BRISTOL 0117 916 1066 ☐ ☐ DUBAI 00 971 4453 4735
www.campbellreith.com