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**NORTH OF BRO TATHAN
BUSINESS PARK,
ST ATHAN, BARRY
PHASE II
ENVIRONMENTAL SITE
ASSESSMENT**

**NORTH OF BRO TATHAN BUSINESS PARK, ST ATHAN,
BARRY
PHASE II ENVIRONMENTAL SITE ASSESSMENT**

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EXECUTIVE SUMMARY

Ramboll UK Limited ("Ramboll") was instructed by F1 Enzo Properties Limited (the "Client"), to undertake a Phase II Environmental Site Investigation (ESA) at land located 'North of Bro Tathan Business Park', St Athan, Barry ("CWL-C" the "site"). The report is required in connection with the proposed purchase of the site by the Client. It is understood that the site will be redeveloped as a data centre.

The Phase II ESA forms part of a geo-environmental ground investigation that was designed to investigate the depth to and integrity of shallow limestone bedrock; test geotechnical properties; and to target the potential historic contamination sources identified at the site.

The site currently comprises an undeveloped parcel of land covering an area of approximately 10.9 hectares. A fire training area is situated in the southernmost part of the site, comprising a replica aeroplane mounted within a circular concrete bund; and stockpiles of overgrown demolition rubble are present across the site. Ramboll's Phase I ESA (Ref. 1620012263-001, dated December 2021) identified that historically the site formed part of the wider RAF St Athan site, used principally for military flights, training and associated activities. The southern part of the site was used as a fire training ground and a 2,000 litre aviation fuel tank was recorded in this area. Additionally, the breaking of aircraft has reportedly occurred at the site, including deposition of radioactive luminised paint dials.

The Phase I ESA identified potential for fire-fighting foams used in the fire training area to have used a group of chemicals referred to as per- and polyfluoroalkyl substances (PFAS). Perfluoro octane (PFOS) was identified in soil and groundwater samples at and in the vicinity of the site during an investigation in 2010. On the basis of the Phase I ESA, Ramboll considered that there is a moderate to high risk of ground contamination being present at the site. Recommendations were made for a site-wide radiological survey, environmental site investigation and an unexploded ordnance assessment.

A radiological survey has been carried out and nine hot spots were identified, interpreted as areas of buried radioactive luminised paint dials. Remediation (excavation) of these hot spots will be required prior to site redevelopment, under an Environmental Permit from Natural Resources Wales (NRW). *The Permit application was made on behalf of the Client by Ramboll in April 2022.*

During the site investigation, ground conditions were encountered in line with published records comprising locally present Made Ground as reworked clay with cobbles of limestone; natural ground (subsoil) as firm to very stiff grey-brown mottled orange clay with limestone gravel; over the Porthkerry Member, limestone bedrock with bands of mudstone.

Groundwater was encountered in all eleven wells, with resting levels declining from the north-west to the south-east, in line with surrounding topography and towards a drainage channel adjacent to the southern site boundary.

Black staining and a hydrocarbon odour were noted within thin beds of very weak mudstone in one borehole location at the centre of the site. Field evidence of contamination was not observed at shallower or deeper depths at this location; and there are no potential current or historical sources of contamination identified at this location.

Risks to Human Health

Whilst localised field evidence of contamination was recorded during the investigation, concentrations of contaminants in excess of the Ramboll GAC for commercial / industrial use have not been detected in samples of soil.

Asbestos was detected in one of the twenty-nine analysed samples of soil. Whilst widespread presence of asbestos has not been identified during the investigation, there is potential for undiscovered asbestos

containing material to be present at the site, particularly associated with the stockpiles of demolition rubble.

PFAS were detected in eight out of fifteen analysed samples of shallow soil, primarily in the vicinity of the fire training area in the south of the site; however, it is noted that PFAS analysis was concentrated in this area. Whilst there are no available assessment criteria for PFAS for human health in a commercial / industrial setting, EA Soil Screening Values (SSVs) for PFOA and PFAS have not been exceeded by analysed samples of soil from this investigation. Overall, the risks to human health from PFAS are considered to be low, due to the absence of a pollutant linkage or pathway.

No groundwater concentrations were detected exceeding the human health pathway for groundwater volatilisation for a commercial / industrial end use (where available). No free phase hydrocarbons were detected in groundwater across the site.

Slightly elevated concentrations of ground gases carbon dioxide (above 5%) and methane (above 1%) have been recorded during one of the monitoring rounds; however, only very low borehole flow rates were recorded, indicating that only limited volumes of ground gas are being generated. The majority of the site is considered to be 'Characteristic Situation 1' (CS1, very low hazard), no specific gas protection measures are considered to be warranted. However, the requirement (or otherwise) and design of any gas protection measures will need to be agreed in consultation with the Local Authority Building Control prior to construction.

The site lies in a "High Probability Radon Affected Area". Radon protection measures are required under building regulations for new buildings at this location.

Risk to Controlled Waters

Several polycyclic aromatic hydrocarbons (PAHs) and one volatile organic compound (VOC) were recorded in groundwater at concentrations exceeding respective GAC for Controlled Waters, associated with observations of black staining and a moderate to strong hydrocarbon odour at the centre of the site. However, exceedances are marginal, and are not indicative of a significant ongoing source of groundwater contamination. Slightly elevated concentrations of PAH were also recorded in groundwater in the south of the site, in the former fire training area.

Slight exceedances of assessment criteria for several total petroleum hydrocarbon (TPH) fractions were noted in three locations. Recorded concentrations are not considered to be significantly elevated or indicative of gross contamination; and there are no known current or historical industrial site uses at these locations.

Whilst groundwater at the site is understood to form a continuous aquifer that extends beneath (and off) the site, identified exceedances are marginal and are not indicative of gross or widespread groundwater contamination. Furthermore, PAHs were not detected in the surface water sample collected from a drainage channel adjacent south of the site, which is considered to be downgradient and is likely to be in hydraulic continuity with groundwater at the site.

PFAS was detected in five of the seven analysed water samples, with maximum concentrations recorded adjacent south of the fire training area (including detection of PFOS, which exceeds the Environmental Quality Standard (EQS)). In the absence of EQS for other PFAS, European drinking water standards were applied to PFAS concentrations recorded in groundwater, which is considered to be a conservative approach given that there are no on-site or adjacent drinking water abstractions. Consequently, all locations where PFAS has been detected exceed the adopted screening criteria.

Risks to Ecological Receptors

PFAS compounds are known to bioaccumulate and there is potential for the habitats on-site to be impacted, specifically the surface water features (both on-site and immediately adjacent).

Ramboll has recommended sampling and analysis of all boreholes installed at the site for PFAS compounds to delineate the extent of PFAS in groundwater; installation of additional monitoring points to delineate the PFAS impact in soil and groundwater; surface water sampling of on-site and off-site drainage channels; groundwater and surface water level monitoring; and a survey of the drainage network associated with the fire testing area. The results of this additional assessment would be used to prepare a Remediation Options Appraisal.

Recommendations have also been made for further investigation of stockpiles containing demolition-type material to determine suitability for re-use on-site; further rounds of ground gas monitoring; implementation of radon protection measures in the design of the proposed development; and a watching brief during ground works to identify any unforeseen ground conditions or localised contamination hotspots, especially during the removal of stockpiles.

1. INTRODUCTION

1.1 Background

This report presents the objectives, scope, findings and conclusions of a Phase II Environmental Site Investigation undertaken at land located 'North of Bro Tathan Business Park', St Athan, Barry ("CWL-C" the "site"). The assessment was undertaken in connection with the proposed purchase of the site and redevelopment as a data centre.

This report has been prepared by Ramboll UK Limited ("Ramboll") on behalf of F1 Enzo Properties Limited (the 'Client').

A Phase I Environmental Assessment of the site has previously been undertaken by Ramboll (Ref. 1620012263-001_03, December 2021).

1.2 Proposed Development

The development comprises three data centre buildings and single sub station with associated plant, equipment, parking and manoeuvring space, landscaping and drainage works. Each 16MW building is arranged over two floors, and comprises of a total of four 4MW Halls (two 4MW Halls on each floor). The Halls are served by generators (four for each floor) to provide emergency power to the computer servers and one generator to provide emergency 'house' power (e.g. emergency lighting in the case of a power cut). Each Hall could potentially be leased separately and each generator is capable of operating independently from one another, depending on the nature of the event requiring emergency power to be generated.

1.3 Objectives

The Phase II ESA forms part of a geo-environmental ground investigation that was designed to investigate the depth to and integrity of shallow limestone bedrock; test geotechnical properties; and to target the potential historic contamination sources identified at the site, specifically the fire training ground in the south. Geotechnical elements are reported separately as Ramboll Ground Investigation Report (GIR) Ref: 1620012263-004_P01.

The objectives of the Phase II Environmental Site Assessment were to:

- document and interpret the environmental ground conditions encountered;
- assess the potential for risks to both human health and environmental receptors (including controlled waters) based on the data collected;
- carry out a contaminated land risk assessment based on a source-pathway-receptor methodology;
- present a refined Conceptual site Model (CSM) based on the findings of the ground investigation;
- provide a commentary on contaminated land risks under the proposed end use; and
- assess the requirement for further investigation, assessment and/or remedial measures.

1.4 Scope of Works

The scope of work undertaken during this investigation was as follows:

- exploratory locations were marked out and cleared by a specialist underground service clearance contractor before the start of intrusive works, in accordance with Ramboll's Health and Safety procedures;

- areas of the site previously identified as potentially hazardous to the ground investigation workers (i.e. radiological hotspots, and open manhole covers / below ground chambers), were segregated from working areas using Heras type fencing;
- drilling of 14 boreholes (BH01 to BH14) using a Comacchio GEO305 multi-rig to depths of up to 10.0m bgl, to facilitate the collection of soil and groundwater samples and allow the assessment of ground conditions for geotechnical and environmental purposes. Eleven of the boreholes were installed with monitoring wells for groundwater (BH01, BH03, BH04-BH06, BH08, BH09, and BH11-BH13);
- excavation of 28 trial pits (TP01-TP27, excluding TP08, and including TP07A and TP12A) using a tracked excavator to depths of up to 3.1m bgl, to facilitate the collection of soil samples and allow the assessment of ground conditions for geotechnical and environmental purposes.
- in-situ Standard Penetration Tests (SPTs) were carried out in boreholes as appropriate for encountered ground conditions; in-situ plate load tests and soak away tests were carried out in trial pits; and samples of soil and rock were collected from each exploratory location and submitted for geotechnical laboratory testing (discussed further in Ramboll's GIR);
- supervision of investigation works by Geotechnical Engineering Ltd (GEL) field engineers, who logged the soil arisings and collected soil samples for in-situ testing of volatile organic compounds and for laboratory analysis;
- overall supervision of investigation works by Ramboll field engineers, who confirmed siting of exploratory locations; and collected soil samples identified for laboratory analysis of per- and polyfluoroalkyl substances (PFAS);
- attendance on site of an unexploded ordnance (UXO) engineer (Zetica Ltd) to monitor for the presence of potential UXOs during site investigation works;
- monitoring of resting groundwater levels, where present within the monitoring wells, followed by collection of groundwater samples;
- submission of selected soil and groundwater samples to a Ramboll approved MCERTs¹ and UKAS² accredited laboratory for analysis for a range of determinands;
- monitoring of each of the installed monitoring wells on three occasions for ground gases (methane, carbon dioxide, oxygen, carbon monoxide, and hydrogen sulphide); and
- the production of an interpretative report, to include comparison of the analytical results with Generic Assessment Criteria (GAC) derived in accordance with UK guidance on risk assessment, a qualitative source-pathway-receptor risk assessment (based on proposed commercial/industrial use of the site) and production of a conceptual site model.

In the preparation of this report Ramboll has made reference to UK regulatory guidance and methodologies, including, but not limited to: Land Contamination: Risk Management (LCRM); BS5930:2015 Code of Practice for site Investigation; and BS10175:2011 + A2:2017 Code of Practice for the Investigation of Potentially Contaminated sites.

1.4.1 Scope of Works Notable Exceptions and Restrictions

- Trial pit TP08 was omitted from the programme due to the overgrown nature of vegetation at the proposed exploratory location; and close proximity of other exploratory locations.
- Additional trial pits TP07A and TP12A were excavated in order to allow plate load tests to be performed in locations that had already been investigated.

¹ Environment Agency's Monitoring Certification Scheme

² United Kingdom Accreditation Service for organisations that provide certification, testing, inspection and calibration services.

- Borehole BH06 was installed as an additional groundwater monitoring well due to the presence of elevated PID readings and a moderate to strong hydrocarbon odour noted during progression of the borehole.
- Boreholes BH01, BH03, and BH05 were installed with additional shallow 19mm diameter gas monitoring standpipes to allow the assessment of shallow ground conditions at these locations. These are identified throughout the report as BH01(S), BH03(S), and BH05(S).
- A surface water sample was collected from a drainage channel located at the southern site boundary; and analysed for the same suite of analysis as groundwater samples.

1.5 General Limitations and Reliance

This report has been prepared by Ramboll exclusively for the intended use by the Client in accordance with the agreement (proposal reference number 1620012263-001), dated 18th February 2022 between Ramboll and the client defining, among others, the purpose, the scope and the terms and conditions for the services. No other warranty, expressed or implied, is made as to the professional advice included in this report or in respect of any matters outside the agreed scope of the services or the purpose for which the report and the associated agreed scope were intended or any other services provided by Ramboll.

In preparation of the report and performance of any other services, Ramboll has relied upon publicly available information, information provided by the client and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to Ramboll was accurate, complete and available to Ramboll within the reporting schedule.

Ramboll's services are not intended as legal advice, nor an exhaustive review of site conditions and/or compliance. This report and accompanying documents are initial and intended solely for the use and benefit of the client for this purpose only and may not be used by or disclosed to, in whole or in part, any other person without the express written consent of Ramboll. Ramboll neither owes nor accepts any duty to any third party, unless formally agreed by Ramboll through that party entering into, at Ramboll's sole discretion, a written reliance agreement.

The site investigation works were undertaken during a discrete period of time. The findings and conclusions presented in this report are accordingly factually limited by these circumstances and, unless stated otherwise in the report, are preliminary. The field investigations were restricted to a level of detail necessary to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant period of time has elapsed since the sampling took place. The interpretation of the geological and environmental quality conditions is based on extrapolation from point-source data in a heterogeneous environment. Accordingly, more detailed investigation may be appropriate dependent upon the client objectives.

1.6 Report Layout

The report is structured as follows:

- Section 1: Describes the background to the report and sets out the objectives of the investigation.
- Section 2: Provides a description of the current site layout and summarises information from the Phase I Environmental Assessment.
- Section 3: Introduces a preliminary conceptual site model for the site, which has been used in designing the investigation strategy and sets out the sampling and analysis rationale.

- Section 4: Details the ground and groundwater conditions and field observations of potential contamination encountered during the investigation.
- Section 5: Summarises the laboratory chemical analysis results for soils and screens the data against risk based generic assessment criteria (GAC) for human health derived by Ramboll.
- Section 6: Summarises the laboratory chemical analysis results for groundwater and screens the data against available water quality standards.
- Section 7: Presents the results of ground gas monitoring and discusses potential risks to the built environment.
- Section 8: Presents a revised conceptual site model based on information obtained during the investigation and sets out a qualitative source-pathway-receptor risk assessment.
- Section 9: Provides a summary and the conclusions and recommendations of the investigation.

2. SITE DESCRIPTION

The site is located to the north of Bro Tathan Business Park, in close proximity to the Ministry of Defence (MoD) St Athan airfield. The site is located approximately 5km west of Cardiff Airport and 19km south-west of Cardiff City Centre, at National Grid Reference 299810, 169550. Access to the site is via Cowbridge Road on the southern site boundary. The natural topography of the site and surrounding area slopes gently down towards the south-west. The location and site layout are shown on Figures 1 and 2 in Appendix 1.

The site is a largely undeveloped parcel of land covering an area of approximately 10.9 hectares. A fire training area is situated in the southernmost part of the site, comprising a replica aeroplane mounted within a circular concrete bund. Stockpiles of overgrown demolition rubble are present across the site; the largest of which is located in the southern portion of the site. A bunker entrance is located in the south-east portion of the site.

2.1 Summary of Previous Reports

Ramboll has previously undertaken a Phase I Environmental Assessment of the site (Ref. 1620012263-001, dated December 2021). The Phase I Environmental Assessment identified that historically the site formed part of the wider RAF St Athan site, which opened in 1938 and was used principally for military flights, training and associated activities. The southern part of the site was used as a fire training ground and involved the burning of vehicles and aircraft. A 2,000 litre aviation fuel tank that did not have secondary containment was recorded in this area. The breaking of aircraft has also reportedly occurred at the site, including deposition of radioactive luminised paint dials.

A radiological walkover survey and ground investigation were undertaken at the site in 2001 and 2002. The radiological survey identified seven hot spots of elevated radiation at the site, and the ground investigation identified elevated metals, polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH) in soil and groundwater.

There is a potential for fire-fighting foams used in the fire training area to have used a group of chemicals referred to as per- and polyfluoroalkyl substances (PFAS). This group of chemicals is receiving increased focus from the regulatory agencies. From the information available to Ramboll, Perfluoro octane (PFOS) was identified in soil samples during an investigation in 2010, as well as within a groundwater sample collected from a monitoring well 500m from the training ground. Further information from the ground investigation has not been provided, including a map or diagram showing the locations where PFOS was identified. Ramboll requested the report detailing these findings from the Welsh Government (the current land owner).

The Environmental Health Department of the Vale of Glamorgan Council has confirmed that the site has not been identified as "contaminated land" under Part 2A of the Environmental Protection Act 1990.

On the basis of the Phase I ESA, Ramboll considered that there is a moderate to high risk of ground contamination being present at the site. Recommendations were made for a site-wide radiological survey, environmental site investigation and an unexploded ordnance assessment.

A radiological survey was carried out between December 2021 and March 2022 by a specialist contractor. Nine hot spots of radiological contamination were identified, interpreted as likely radium dials from historical aircraft. The excavation of these hot spots will be required prior to site redevelopment. *Ramboll has made an application to Natural Resources Wales (NRW) on behalf of the Client for an Environmental Permit to remediate radiological contamination.*

In order to support detailed geotechnical assessment, recommendations were made for a ground investigation to characterise the ground model. Ramboll recommended that the geotechnical and environmental assessments are carried out concurrently, i.e. the same exploratory locations used for geotechnical and environmental sampling.

According to the NRW fluvial and tidal flood map for planning , the site is located entirely in Zone A; and therefore has little to no flood risk from rivers, sea, reservoirs or dams. There are no known records of historic flooding at Bro Tathan Business Park.

There are areas of High, Medium and Low risk of surface water flooding in the west of the site. There are flood bunds in place for attenuation of this surface water, however the proposed development has reconfigured the flood attenuation bunds on site to ensure suitable space for the development as well storage of water. The impermeable area of the site will also increase as part of the development, and therefore surface water runoff will increase. *Ramboll is currently in the process of modelling flood risk from the proposed development to demonstrate the manageability of risks – this will be reported separately upon finalisation of the proposed site design.*

3. SITE INVESTIGATION STRATEGY

3.1 Preliminary Conceptual Site Model

The preliminary conceptual site model is a simplified representation of the environmental conditions at the site, and in the vicinity of the site, and is used to initially identify potentially sensitive receptors and potential pollutant linkages. Information obtained during the environmental site investigation, described in the following sections of this report, is then used to refine and update this preliminary conceptual model.

Table 3.1: Preliminary Conceptual Site Model

<p>Potential Sources of Contamination</p> <p>Former use as an airfield.</p> <p>Former above ground fuel storage (historical 20,000L aviation fuel tank).</p> <p>Fire testing area including the use of combustible fuels and fire-fighting foam.</p> <p>Elevated concentrations of metals, PAHs and TPH in soil and groundwater identified in previous ground investigations.</p> <p>Potential contaminants may include metals, organic contaminants including PAH and TPH, and PFAS.</p> <p>Migration of radon gas into buildings and structures.</p>	
<p>Geology</p> <p>The geology of the site is expected to comprise bedrock of the Porthkerry Member, recorded on geological mapping as comprising interbedded limestone and mudstone.</p> <p>Previous ground investigations undertaken at the site identified ground conditions on-site and in the surrounding area to be as follows:</p> <ul style="list-style-type: none"> • Topsoil comprising soft dark brown sandy clay from ground level to 0.3m (bgl); underlain by • Made Ground comprising tarmac, metalliferous ash, concrete, plastic sheeting, brick and occasional pottery fragments up to 0.6m bgl; underlain by • Bedrock comprising moderately strong to strong crystalline limestone, thinly to medium bedded, occasionally interbedded with very weak bands of fine grained mudstone, from 0.6m to an unproven depth (greater than 12.0m bgl). 	
<p>Hydrogeology</p> <p>The bedrock underlying the site is classified as a Secondary A Aquifer. The site is not situated in a Natural Resources Wales (NRW) designated source protection zone (SPZ). There are no groundwater abstractions for public water supply recorded in environmental database records within a 2km radius of the site. Overall the site is considered to be of moderate environmental sensitivity in terms of groundwater.</p>	
<p>Hydrology</p> <p>On site drainage channels flow in a broadly south-westerly direction towards Boverton Brook, located approximately 170m south-west of the site. There are two watercourses within 2km of the site classified by NRW under the Water Framework Directive. There are no surface water abstractions within 2km of the site.</p> <p>According to the NRW fluvial and tidal flood map for planning , the site is located entirely in Zone A; and therefore has little to no flood risk from rivers, sea, reservoirs or dams. There are no known records of historic flooding at Bro Tathan Business Park.</p> <p>There are areas of High, Medium and Low risk of surface water flooding in the west of the site. There are flood bunds in place for attenuation of this surface water, however the proposed development has reconfigured the flood attenuation bunds on site to ensure suitable space for the development as well storage of water. The impermeable area of the site will also increase as part of the development, and therefore surface water runoff will increase.</p>	
<p>Potential Receptors to Contamination (if Present)</p>	<p>Receptor Present?</p>

Human Health	On-site	The site is proposed to be redeveloped as a data centre.	Yes
	Off-site	Aerospace Business Park is located to the east of the site; and Bro Tathan Business Park is located to the south of the site.	Yes
Water Environment	On-site	Groundwater is expected to be present in the Porthkerry Member (limestone and mudstone) bedrock underlying the site.	Yes
	Off-site	Groundwater: The site is located on a Secondary A Aquifer.	Yes
		Surface Water: On-site drainage channels drain to Boverton Brook, approximately 170m south-west of the site.	Yes
Ecological Receptors	On-site	There are no statutory designated ecologically sensitive sites present on-site. However, a Phase 1 habitat survey, undertaken in July 2021, identified that a number of protected species have the potential to be present on the site and surveys were recommended prior to submitting a planning application for the development of the site. Potential ecological receptors are the on-site water features and species that thrive within these habitats such as amphibians, reptiles, waterfowl and fish. Burrowing species such as rabbits, foxes and badgers could also be receptors to contaminants in soil (if present).	Yes
	Off-site	There are no statutory designated ecologically sensitive sites within a 2km radius of the site; however, nearby watercourse habitats could be affected by contamination (if present).	Yes
Built Environment	On-site	The proposed site use is for commercial / industrial use.	Yes

The site investigation strategy was designed to assess the key potential contamination sources and potential pollutant linkages identified in the preliminary conceptual site model. The following sections describe the site investigation strategy, the results of laboratory chemical analysis and a qualitative source-pathway-receptor risk assessment; the revised conceptual model is then presented in Section 8.

3.2 Site Investigation Works

The intrusive site investigation was undertaken between the 15th March and 1st April 2022 and was supervised by Geotechnical Engineering Ltd (GEL), with oversight provided by Ramboll.

3.2.1 Summary of Intrusive Works

A summary of the scope of the investigation undertaken at the site is presented in Table 3.2 below. Exploratory locations are shown on Figure 2, Appendix 1. Borehole logs (including monitoring well details) are provided in Appendix 2.

Table 3.2: Summary of Intrusive Works

Item	No.	Comments
Utilities Clearance Survey	Item	Prior to intrusive works a specialist service location contractor, GEL, was contracted to locate below ground services and mark out drilling locations.
Rotary Boreholes	14 No.	A Comaccio GEO305 multi-rig was used to advance ten boreholes to depths of 10.0m bgl; and four boreholes to depths of 5.0m bgl. Of the above locations, eleven monitoring wells were installed for ground gas monitoring, and/or groundwater monitoring purposes (BH01, BH03, BH04-BH06, BH08, BH09, and BH11-BH13). Wells were of appropriate construction for the ground conditions encountered. The well designs are detailed within the borehole logs presented in Appendix 2.
Trial Pits	28 No.	A tracked excavator was used to advance 28 trial pits to depths of up to 3.1m bgl (TP01-TP27, excluding TP08, and including TP07A and TP12A), to facilitate the collection of soil samples and allow the assessment of ground conditions for geotechnical and environmental purposes.
Soil Sampling and Analysis	89 No.	During the site investigation, soil samples were recovered from each exploratory hole location and screened on-site using a hand-held photo-ionisation detector (PID) for the presence of volatile organic compounds. Up to four soil samples from each sampling location were submitted for selected laboratory analysis. Selected soil samples were analysed for a predetermined suite of contaminants (see Section 3.4), designed to be reflective of the site's historic uses.
Groundwater Sampling and Analysis	13 No.	Groundwater was encountered in all of the eleven installed monitoring wells. An oil/water interface probe was used to check for free-phase hydrocarbons and resting groundwater levels were monitored. Groundwater samples were analysed for a suite of contaminants (see Section 3.4) designed to be reflective of the site's historic uses. A duplicate sample was collected from borehole BH12; and submitted, along with a field blank, for laboratory analysis for PFAS.
Surface Water Sampling and Analysis	1 No.	A surface water sample was collected from a drainage channel located at the southern site boundary; and analysed for the same suite of analysis as groundwater samples.
Gas Monitoring	3 No.	Three rounds of ground gas monitoring were undertaken on the 7 th , 13 th , and 20 th April 2022 using a portable gas analyser (GFM 436).

3.2.2 Sample Location Rationale

Exploratory locations were positioned to provide coverage of the site, based on the redevelopment proposal as a data centre. The geo-environmental ground investigation was designed to investigate the depth to and integrity of shallow limestone bedrock; test geotechnical properties; and to target the potential historic contamination sources identified at the site, specifically the fire training ground in the south.

Samples located within the fire training ground include those from BH12, TP24, and TP23; with samples from BH11, BH13, and TP22 located within the vicinity of the fire training ground. An exploratory hole location plan is provided in Appendix 1.

Geotechnical elements are reported separately as Ramboll Ground Investigation Report (GIR) Ref: 1620012263-004_P01.

3.2.3 Limitations to the Investigation

The site investigation was limited by the following factors:

- Trial pit TP08 was omitted from the programme due to the overgrown nature of vegetation at the proposed exploratory location; and close proximity of other exploratory locations.

Overall, Ramboll was able to investigate the majority of identified potential contaminant sources and it is considered that the exploratory holes provide reasonable coverage across the accessible areas of the site. It should be noted that ground conditions at variance with those recorded in the exploratory holes drilled and excavated at the site could exist in areas of the site (e.g. beneath the building) that could not be accessed.

3.3 Sampling and Monitoring

3.3.1 Soil Samples

Soil samples were recovered from each of the exploratory locations based at regular intervals and/or changes of strata. Samples were collected in accordance with BS 10175:2011+A2:2017 and were stored within appropriate sample containers and forwarded to an independent Ramboll approved MCERTS accredited analytical laboratory (Element Materials Technology Ltd). Selected samples were placed in containers supplied by the laboratory appropriate to the type of analysis being undertaken and stored in cool boxes with ice packs. All samples were dispatched accompanied by chain of custody documentation.

Selected soil samples were tested on-site for the presence of volatile organic compounds (VOCs) using a photo-ionisation detector (PID), calibrated in accordance with Ramboll's Quality Management procedures. Each soil sample tested was placed into a sealed plastic bag and agitated. The PID was then inserted into the headspace and the total VOC reading recorded. The PID screens for a wide range of VOCs but does not indicate a specific compound; therefore, the results of the PID screening provide a semi-quantitative indication of the concentration of VOCs present in soil pore spaces. The results of the PID screening are discussed in Section 4.4.

3.3.2 Groundwater Samples

Groundwater sampling was undertaken on 13th April 2022, following the completion of the site investigation. Prior to sampling, the depth to the resting groundwater level (where present) and base of the monitoring wells were measured using an electronic interface probe. The wells were then purged of more than three times the well volume prior to groundwater sampling. Sampling was undertaken using a dedicated inert disposable bailer to prevent cross contamination.

The recovered samples were placed in containers supplied by the laboratory appropriate to the type of analysis being undertaken and stored in cool boxes with ice packs. All samples were dispatched accompanied by chain of custody documentation to Ramboll's subcontracted and suitably accredited laboratory (Element Material Technology) for analysis.

3.3.3 Ground Gas Monitoring

A programme of gas monitoring was undertaken by Ramboll comprising three monitoring visits undertaken between the 7th and 20th April 2022. Ground gas monitoring was completed using a calibrated GFM436 Monitor with reference to CIRIA C665 and BS 8576:2013 Guidance on Investigations for Ground Gas. The monitoring was undertaken during periods of high, moderate and falling pressure. The following parameters were monitored:

- Methane (% vol);
- Carbon dioxide (% vol);

- Oxygen (% vol);
- Carbon Monoxide (ppm);
- Hydrogen Sulphide (ppm); and
- Flow rate (l/hr).

Gas flow rates were measured at all monitoring boreholes and Ramboll recorded the range in flow rates until a steady state was reached. The results of the ground gas monitoring are discussed in Section 7.

3.4 Laboratory Analysis

3.4.1 Analytical Rationale

Table 3.3 summarises the analytical schedule for soil and groundwater samples together with the rationale for analysis.

Table 3.3: Summary of Analytical Strategy

Analytical Suite	Rationale	No. of soil samples submitted	No. of groundwater samples submitted
Total Petroleum Hydrocarbons Carbon Working Group (TPH CWG) including BTEX	Typically associated with fuels and oils.	60	11
Total cyanide, phenols	Typically associated with historical industrial sites and brownfield land	60	11
Asbestos Screen	Commonly associated with Made Ground.	29	N/A
Metals (including arsenic, cadmium, chromium, lead, mercury, copper, nickel, zinc vanadium, boron, beryllium and selenium)	Typically associated with brownfields sites historically used for industrial purposes.	60	11
Water soluble sulphate	Typically associated with Made Ground.	60	11
Polycyclic Aromatic Hydrocarbons (PAH)	Typically associated with fuels and oils.	60	11
Volatile Organic Compounds (VOCs) and Semi Volatile Organic Compounds (SVOCs)	Typically associated with solvents and cleaners.	30	6
Per- and Polyfluoroalkyl Substances (PFAS)	Typically associated with fire-fighting foam.	15	6
Total hardness (as calcium carbonate), calcium, dissolved organic carbon	Used to derive assessment criteria for some metals.	N/A	11

3.4.2 Data Quality Assurance

The laboratory selected to perform the analysis is accredited by UKAS to ISO 17025 and MCerts standards. Internal quality assurance checks are carried out by the laboratory data prior to the laboratory certificates being issued.

Additionally, Ramboll took a duplicate groundwater sample (from BH12). Review of the analytical results confirmed it to be comparable with the associated sample analytical results, thereby confirming the laboratory's analytical techniques to be appropriately replicable. Ramboll also prepared a field blank, by decanting deionised water into sampling containers at BH12. The field blank was analysed for PFAS and none were detected.

4. FIELD OBSERVATIONS

4.1 Ground Conditions

Ground conditions are summarised in Table 4.1 below. The information provided below is a summary of findings in both the trial pits locations and the deeper borehole locations. A full lithological description is recorded on the logs, which are presented in Appendix 2.

Table 4.1: Summary of Ground Conditions

Strata	Description	Depth to Base (m bgl)	Approx. Ave. Thickness (m)
Topsoil	Grass over firm orange-brown slightly gravelly silty clay.	0.15 – 0.90	0.50
Made Ground	Made Ground (i.e. anthropogenic material deposits overlying natural deposits) is present as reworked natural materials of clay with cobbles of limestone to depths of up to 2.65m bgl. The depth to the base of Made Ground remained unproven in two locations (TP13, 1.20m bgl; and TP20, 0.90m bgl). Locally, Made Ground was recorded to include fragments of metal, wood, brick, concrete, and ceramic. Made Ground was typically not recorded in the south-west and south-east of the site.	0.50 – 2.65, where encountered	0.60, where encountered and proven
Subsoil	Firm to very stiff grey-brown mottled orange clay with gravel of limestone was recorded to depths of up to 3.75m bgl. With the exception of trial pits TP07A, TP13, and TP20, all trial pits terminated at the base of this strata.	0.90 – 3.75, where encountered	1.50, where encountered and proven
Porthkerry Member (bedrock)	Interbedded strong grey limestone and weak dark grey-brown mudstone.	>10.0m, unproven	>6.25m, unproven

The ground conditions encountered across the site are generally comparable to the geology described in the British Geological Survey (BGS) map of the area.

No evidence of unexploded ordnance was encountered during the investigation at any of the investigation locations.

4.2 Groundwater

The depth to resting groundwater level was recorded during Ramboll's groundwater monitoring round on 7th April 2022 and also during the two subsequent gas monitoring rounds. A summary of the groundwater levels throughout the monitoring period is provided in Table 4.2.

Table 4.2: Summary of Groundwater Observations

Exploratory Hole	Borehole Level (m AOD)	Depth to Groundwater (m bgl)	Depth to Groundwater (m AOD)	Inferred Horizon Containing Groundwater ¹
BH01	42.57	0.84 – 1.42	41.73 – 41.15	Limestone bedrock
BH01(S)	42.57	1.00 – 1.53	41.57 – 41.04	Clay subsoil
BH03	41.98	1.04 – 1.34	40.94 – 40.64	Limestone bedrock

Exploratory Hole	Borehole Level (m AOD)	Depth to Groundwater (m bgl)	Depth to Groundwater (m AOD)	Inferred Horizon Containing Groundwater ¹
BH03(S)	41.98	1.04 – 1.26	40.94 – 40.72	Clay subsoil
BH04	43.97	2.95 – 3.30	41.02 – 40.67	Limestone bedrock
BH05	42.38	1.82 – 1.96	40.56 – 40.42	Limestone bedrock
BH05(S)	42.38	Dry	NA	Clay subsoil
BH06	43.88	2.81 – 3.19	41.07 – 40.69	Limestone bedrock
BH08	46.77	5.36 – 5.97	41.41 – 40.80	Limestone bedrock
BH09	43.91	3.70 – 4.00	40.21 – 39.91	Limestone bedrock
BH11	41.53	1.60 – 1.79	39.93 – 39.74	Limestone bedrock
BH12	41.61	1.57 – 1.69	40.04 – 39.92	Limestone bedrock
BH13	41.69	1.15 – 1.30	40.54 – 40.39	Clay subsoil / Limestone bedrock
BH14	42.08	1.11 – 1.29	40.97 – 40.79	Clay subsoil / Limestone bedrock
Notes:				
¹ The inferred horizon has been identified by comparing the resting groundwater levels against the exploratory hole logs and monitoring well design.				

Groundwater was encountered in all eleven wells during groundwater monitoring on the 7th April 2022, at resting levels of between 41.73m AOD at BH01 and 39.93m AOD at BH11. This gives a variation in groundwater elevation of 1.80m across the site declining from the north-west to the south-east (see Figure 3, Appendix 1). Given these differences in groundwater elevation across the site it is likely that the groundwater flow direction beneath the site is in an approximate south-easterly direction, which is in line with the surrounding topography; and towards a drainage channel adjacent to the southern site boundary.

4.3 Field Evidence of Contamination

4.3.1 Soils

Black staining and a moderate to strong hydrocarbon odour were noted in BH06 in the Porthkerry Member limestone bedrock, within thin beds of very weak mudstone between 2.10m and 2.90m bgl. No field evidence of contamination was observed above or below these depths at this location. There are no potential sources of contamination identified in current or historical use of the site at this location.

Soil headspace screening for volatile organic compounds was recorded using a photo-ionisation detector (PID) for selected soil samples. PID concentrations were all below the instrument's limit of detection, other than in BH06 where concentrations of up to 346ppm v/v were recorded in association with black staining and a hydrocarbon odour.

4.3.2 Groundwater

During Ramboll's groundwater sampling, no visual or olfactory evidence of contamination was noted; and free phase hydrocarbons were not detected in the groundwater.

4.4 Ground Gas Monitoring

A summary of the ground gas concentrations recorded over three monitoring rounds undertaken on 7th, 13th and 20th April 2022 is provided in Table 4.3 below. The maximum flow rate was 2L/hr. Full ground gas monitoring results are provided in Appendix 3 and an assessment of the results is presented in Section 7.

Table 4.3: Summary of Ground Gas Monitoring Results

Ground Gas	Conc. Range	Location of Min. Conc.	Location of Max. Conc.
Methane (% vol)	<0.1 – 2.4	N/A	BH05(S)
Carbon Dioxide (% vol)	<0.1 – 5.6	N/A	BH08
Carbon Monoxide (ppm)	<10	N/A	N/A
Hydrogen Sulphide (ppm)	<10 – 73	N/A	BH12
Oxygen (% vol)	3.8 – 21.2	BH05(S)	BH11
VOC (ppmv)	<0.1 – 10.2	N/A	N/A

Monitoring was undertaken under moderate and low atmospheric pressure conditions, the atmospheric pressure was recorded as steady or rising in the 24 hours prior to the monitoring.

5. HUMAN HEALTH ASSESSMENT

5.1 Assessment Approach

The main environmental legislation relating to contaminated land in the UK is Part 2A of the Environmental Protection Act 1990. The philosophy behind Part 2A is the source-pathway-receptor linkage; for land to be contaminated, all three aspects of this linkage must be present (i.e. a contaminant must be present and able to move along a pathway and impact a receptor).

Ramboll has derived generic assessment criteria (GAC) for the interpretation of soil and groundwater chemical analyses. The GAC are threshold, based screening criteria below which a significant risk is not considered to be present. Contaminants at concentrations above the GAC do not infer an unacceptable risk; rather that further assessment is required to more fully understand potential contamination risks (as discussed below).

Full details of Ramboll's assessment methodology are presented in Appendix 4.

5.2 Analytical Results

5.2.1 Soils

The soil analytical results obtained during this investigation have been screened against the Ramboll GAC for commercial / industrial end use. The results of the screening are summarised in Table 5.1 below.

The following determinands were not detected above the laboratory method reporting limits and are therefore not presented in the table:

- Hexavalent chromium;
- Aliphatic TPH fractions C5-C6;
- Aromatic TPH fractions C5-C10;
- Methyl Tertiary Butyl Ether (MTBE);
- BTEX compounds, benzene and ethylbenzene;
- The majority of VOCs and SVOCs (except those listed in the table); and
- PFAS (except those listed in the table).

The analytical certificates for soils are presented in full in Appendix 5. Exceedance of a Ramboll GAC does not infer that an unacceptable risk is present; the outcome of the screening is assessed further in the context of a qualitative source-pathway-receptor risk assessment presented in Section 8.

Table 5.1: Summary of Soil Analytical Results

Determinand		No. of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg) and location (m bgl)	Ramboll GAC for Commercial / Industrial use (mg/kg)	No. of GAC Exceedances	Location of Exceedance
Metals							
Arsenic		65	2.0	22.1 (TP03, 0.30m)	640	0	N/A
Beryllium		65	<MRL	3.7 (TP15, 1.00m)	12	0	N/A
Cadmium		65	<MRL	9.6 (TP14, 0.30m)	410	0	N/A
Chromium		65	10.7	92.3 (TP02, 0.30m)	8,600	0	N/A
Copper		65	4	2,379 (TP15, 0.30m)	68,000	0	N/A
Lead		65	5	282 (TP15, 0.30m)	2,300	0	N/A
Mercury		65	<MRL	0.3 (TP23, 1.00m)	1,100	0	N/A
Nickel		65	3.0	57.2 (BH01, 0.30m)	980	0	N/A
Selenium		65	<MRL	3 (TP02, 0.30m)	12,000	0	N/A
Vanadium		65	7	64 (TP07, 0.30m)	9,000	0	N/A
Water Soluble Boron		65	0.2	4.2 (TP02, 0.30m)	240,000	0	N/A
Zinc		65	9	669 (TP15, 0.30m)	730,000	0	N/A
Total Petroleum Hydrocarbons							
Aliphatics	C6-C8	65	<MRL	1.1 (BH06, 2.90m)	5,300	0	N/A
	C8-C10	65	<MRL	9.1 (BH06, 2.15m)	1,300	0	N/A
	C10-C12	65	<MRL	95.7 (BH06, 2.90m)	6,100	0	N/A
	C12-C16	65	<MRL	95 (BH06, 2.90m)	43,000	0	N/A
	C16-C21	65	<MRL	52 (TP24, 0.30m)	1,000,000	0	N/A
	C21-C35	65	<MRL	482 (BH12, 0.50m)	1,000,000	0	N/A

Determinand		No. of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg) and location (m bgl)	Ramboll GAC for Commercial / Industrial use (mg/kg)	No. of GAC Exceedances	Location of Exceedance
Aromatics	C8-C10	65	<MRL	0.1 (BH06, 2.15m)	2,200	0	N/A
	C10-C12	65	<MRL	17.2 (BH06, 2.90m)	11,000	0	N/A
	C12-C16	65	<MRL	39 (BH06, 2.90m)	35,000	0	N/A
	C16-C21	65	<MRL	346 (TP15, 0.30m)	29,000	0	N/A
	C21-C35	65	<MRL	1,144 (BH12, 0.50m)	29,000	0	N/A
BTEX Compounds							
Toluene		65	<MRL	0.008 (BH06, 0.30m)	33,000	0	N/A
m/p-Xylene		65	<MRL	0.024 (TP14, 0.30m)	9,400	0	N/A
o-Xylene		65	<MRL	0.008 (TP14, 0.30m)	9,900	0	N/A
Polyaromatic Hydrocarbons							
Naphthalene		65	<MRL	1.59 (TP23, 0.30m)	110	0	N/A
Acenaphthylene		65	<MRL	1.43 (TP23, 0.30m)	76,000	0	N/A
Acenaphthene		65	<MRL	2.15 (TP23, 0.30m)	75,000	0	N/A
Fluorene		65	<MRL	2.14 (TP23, 0.30m)	60,000	0	N/A
Phenanthrene		65	<MRL	26.61 (TP23, 0.30m)	22,000	0	N/A
Anthracene		65	<MRL	7.7 (TP23, 0.30m)	520,000	0	N/A
Fluoranthene		65	<MRL	38.24 (TP15, 0.30m)	23,000	0	N/A
Pyrene		65	<MRL	31.25 (TP15, 0.30m)	54,000	0	N/A
Benzo(a)anthracene		65	<MRL	20.32 (TP27, 0.30m)	76	0	N/A
Chrysene		65	<MRL	20.42 (TP27, 0.30m)	See Benzo(a)pyrene	0	N/A
Benzo(b)fluoranthene		65	<MRL	23.57 (TP15, 0.30m)	See Benzo(a)pyrene	0	N/A

Determinand	No. of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg) and location (m bgl)	Ramboll GAC for Commercial / Industrial use (mg/kg)	No. of GAC Exceedances	Location of Exceedance
Benzo(k)fluoranthene	65	<MRL	9.16 (TP15, 0.30m)	See Benzo(a)pyrene	0	N/A
Benzo(a)pyrene	65	<MRL	16.88 (TP15, 0.30m)	76	0	N/A
Indeno(123cd)pyrene	65	<MRL	14.92 (TP15, 0.30m)	See Benzo(a)pyrene	0	N/A
Dibenzo(ah)anthracene	65	<MRL	3.71 (TP15, 0.30m)	See Benzo(a)pyrene	0	N/A
Benzo(ghi)perylene	65	<MRL	12 (TP15, 0.30m)	See Benzo(a)pyrene	0	N/A
Volatile Organic Compounds						
Chloromethane	30	<MRL	0.004 (TP06, 0.30m)	0.56	0	N/A
Dichloromethane (DCM)	30	<MRL	0.016 (TP24, 0.30m)	130	0	N/A
Isopropylbenzene	30	<MRL	0.041 (BH06, 2.90m)	710	0	N/A
Propylbenzene	30	<MRL	0.094 (BH06, 2.90m)	2,100	0	N/A
tert-Butylbenzene	30	<MRL	0.030 (BH06, 2.90m)	NC	N/A	N/A
1,2,4-Trimethylbenzene	30	<MRL	0.446 (BH06, 2.90m)	22	0	N/A
sec-Butylbenzene	30	<MRL	0.549 (BH06, 2.90m)	75,000	0	N/A
n-Butylbenzene	30	<MRL	0.645 (BH06, 2.90m)	83,000	0	N/A
Semi Volatile Organic Compounds						
2,4-Dimethylphenol	30	<MRL	0.022 (TP15, 0.30m)	13,000	0	N/A
4-Methylphenol	30	<MRL	0.036 (TP15, 0.30m)	160,000	0	N/A
2-Methylnaphthalene	30	<MRL	0.693 (TP23, 0.30m)	710,000	0	N/A
Bis(2-ethylhexyl) phthalate	30	<MRL	0.726 (TP15, 0.30m)	85,000	0	N/A
Butylbenzyl phthalate	30	<MRL	0.124 (TP15, 0.30m)	940,000	0	N/A
Carbazole	30	<MRL	2.114 (TP23, 0.30m)	900	0	N/A

Determinand	No. of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg) and location (m bgl)	Ramboll GAC for Commercial / Industrial use (mg/kg)	No. of GAC Exceedances	Location of Exceedance
Dibenzofuran	30	<MRL	2.140 (TP23, 0.30m)	6,700	0	N/A
Per- and Polyfluoroalkyl Substances						
PFPeA	15	<MRL	0.005 (BH12, 1.00m)	NC	N/A	N/A
PFHxA	15	<MRL	0.005 (BH12, 1.00m)	NC	N/A	N/A
PFHpA	15	<MRL	0.001 (BH12, 1.00m)	NC	N/A	N/A
PFHxS	15	<MRL	0.003 (TP24, 0.30m)	NC	N/A	N/A
PFOA	15	<MRL	0.004 (BH12, 1.00m)	0.022 (A)	0	N/A
PFOS	15	<MRL	0.008 (BH13, 1.00m)	0.014 (A)	0	N/A
PFDA	15	<MRL	0.001 (BH12, 1.00m)	NC	N/A	N/A
Additional Organics						
Phenols	65	<MRL	0.19 (TP12, 0.30m)	380	0	N/A
Asbestos						
Asbestos Screen	29	No detection	Detection	Detection	1	TP14, 0.30m
Notes: MRL – Method reporting limit NC – No criteria available N/A – Not applicable A – Environment Agency (EA) Soil Screening Value (SSV)						

5.2.2 Groundwater (Human Health)

The groundwater analytical results obtained during this investigation have been screened against the Ramboll GAC for commercial / industrial end use. The results of the screening are summarised in Table 5.2 below.

The following determinands were not detected above the laboratory method reporting limits and are therefore not presented in the table:

- PAH dibenzo(ah)anthracene;
- Aliphatic TPH fractions C6-C10;
- Aromatic TPH fractions C5-C10 and C16-C35;
- Methyl Tertiary Butyl Ether (MTBE);
- BTEX compounds other than benzene;
- The majority of VOCs (except those listed in the table);
- SVOCs; and
- Phenols.

With the exception of mercury, there is no volatilisation pathway for inorganic determinands, and therefore metals are not included in Table 5.2. PFAS are also not included in the table for the same reason. Groundwater analytical certificates are presented in Appendix 6.

Exceedance of a Ramboll GAC does not infer that an unacceptable risk is present; the outcome of the screening is assessed further in the context of a qualitative source-pathway-receptor risk assessment presented in Section 8.

Table 5.2: Summary of Groundwater Analytical Results (Commercial / Industrial)

Determinand	Conc. Range (µg/l)	Location of Max. Conc.	Ramboll Water GAC for Human Health (Commercial / Industrial) (µg/l)	No. and Location of Exceedances	
Polycyclic Aromatic Hydrocarbons					
Naphthalene	<MRL - 0.4	BH12	23,000	0	
Acenaphthylene	<MRL - 0.01	BH12	20,000,000	0	
Acenaphthene	<MRL - 0.065	BH12	15,000,000	0	
Fluorene	<MRL - 0.028	BH12	18,000,000	0	
Phenanthrene	<MRL - 0.047	BH12	NC	N/A	
Anthracene	<MRL - 0.009	BH12	NC	N/A	
Fluoranthene	<MRL - 0.033	BH12	NC	N/A	
Pyrene	<MRL - 0.027	BH12	NC	N/A	
Benzo(a)anthracene	<MRL - 0.018	BH12	NC	N/A	
Chrysene	<MRL - 0.018	BH12	NC	N/A	
Benzo(a)pyrene	<MRL - 0.01	BH12	NC	N/A	
Indeno(123cd)pyrene	<MRL - 0.009	BH12	NC	N/A	
Benzo(ghi)perylene	<MRL - 0.008	BH12	NC	N/A	
Benzo(b)fluoranthene	<MRL - 0.022	BH12	NC	N/A	
Benzo(k)fluoranthene	<MRL - 0.009	BH12	NC	N/A	
Total Petroleum Hydrocarbons					
Aliphatics	C5-C6	<MRL - 55	SW01	190,000	0
	C10-C12	<MRL - 51	BH05	3,600	0
	C12-C16	<MRL - 120	BH03	NC	N/A

Determinand		Conc. Range (µg/l)	Location of Max. Conc.	Ramboll Water GAC for Human Health (Commercial / Industrial) (µg/l)	No. and Location of Exceedances
	C16-C21	<MRL - 300	BH03	NC	N/A
	C21-C35	<MRL - 90	BH03	NC	N/A
Aromatics	C10-C12	<MRL - 56	BH12	660,000	0
	C12-C16	<MRL - 70	BH12	3,700,000	0
Volatile Organic Compounds					
Chloroform		<MRL - 3	BH06	NC	N/A
Benzene		<MRL - 1.5	BH06	NC	N/A
Notes: MRL - Method reporting limit NC - No criteria available N/A - Not applicable					

5.3 Discussion of Results

5.3.1 Soils

Asbestos

Samples from the Made Ground and/or surface soil were analysed for the presence of asbestos fibres; asbestos was detected in one of the twenty-nine samples that were analysed (TP14 at 0.30m bgl). Asbestos containing material was not recorded as being present in the Made Ground in any locations during excavation. Whilst widespread presence of asbestos has not been identified during the investigation, there is potential for undiscovered asbestos containing material to be present at the site, particularly associated with the stockpiles of demolition rubble.

Inorganics

Inorganic substances were not detected above the GAC (where available) in any of the Made Ground or Natural Ground obtained during this site investigation.

Organics

Organic substances were not detected above the GAC (where available) in any of the Made Ground or Natural Ground obtained during this site investigation.

PFAS

Fifteen samples were analysed for a suite of 18 per- and polyfluoroalkyl substances (PFAS). Seven different PFAS were recorded at concentrations greater than the laboratory method reporting limit; with at least one PFAS detected in eight out of the fifteen analysed samples.

The majority of maximum concentrations were recorded in BH12 at a depth of 1.00m bgl, at the base of the Made Ground. BH12 is located adjacent south of the fire-training area. PFAS was primarily detected in the vicinity of the fire training area in the south of the site; however, it is noted that PFAS analysis was concentrated in this area. PFAS was analysed and not detected in soil samples from TP06 in the north of the site and TP22 and BH11 in the south-east of the site.

There are no available assessment criteria for PFAS for human health in a commercial / industrial setting. However, EA Soil Screening Values (SSVs) have been provided for PFOA (0.022mg/kg) and PFAS (0.014mg/kg). SSVs are defined by the EA as levels of chemicals in soil below which there is unlikely to be any risk to its health and functions. Neither of these two SSVs have been exceeded by analysed samples of soil from this investigation.

5.3.2 Groundwater (Human Health)

No groundwater concentrations were detected exceeding the human health pathway for groundwater volatilisation for a commercial / industrial end use (where available).

5.3.3 Construction Workers

This report and the generic assessment criteria (GAC) consider long term and chronic risk to humans based on defined exposure scenarios set out in the Contaminated Land Exposure Assessment (CLEA) model. In some cases contaminants may also pose acute hazards to workers at a site, or a worker's exposure scenario may differ from the scenarios considered when deriving the GAC.

As exposure times for construction workers are generally short term, risks from site contamination are generally addressed through the use of appropriate working procedures and the use of personal protective equipment (PPE) in line with the Management of Health and Safety at Work Regulations (1999), Construction (Design and Management) Regulations (2015) for

some sites and the Control of Substances Hazardous to Health Regulations (2002). This potential source-pathway-receptor linkage is considered further in Section 8.

6. WATER ENVIRONMENT ASSESSMENT

6.1 Assessment Approach

In the absence of relevant published water assessment criteria, the potential risk to the aquatic environment from entry of pollutants (either directly or via a groundwater pathway) has been assessed using commonly accepted UK guidelines including country specific Water Regulations and the Environmental Quality Standards (EQS) defined in European legislation such as the Water Framework Directive (WFD) (2000/60/EC).

For those determinands included in the analytical suite which do not have corresponding UK screening criteria derived from the above sources, reference is made to a hierarchy of international guidance in accordance with Environment Agency guidance.

Full details of Ramboll's assessment methodology are presented in Appendix 4.

6.2 Analytical Results

The results of the screening are summarised in Table 6.1 below.

The following determinands were not recorded above the laboratory method reporting limit in any samples; and are therefore not presented in the table:

- Metals: arsenic, beryllium, cadmium, chromium, copper, lead, mercury, selenium, vanadium, and zinc;
- PAH dibenzo(ah)anthracene;
- Aliphatic TPH fractions C6-C10;
- Aromatic TPH fractions C5-C10 and C16-C35;
- Methyl Tertiary Butyl Ether (MTBE);
- BTEX compounds other than benzene;
- The majority of VOCs (except those listed in the table);
- SVOCs;
- Phenols; and
- PFAS (except those listed in the table).

Groundwater analytical certificates are presented in Appendix 6. Exceedance of screening criteria does not infer that an unacceptable risk is present; the outcome of the screening is assessed further in the context of a qualitative source-pathway-receptor risk assessment presented in Section 8.

Table 6.1: Summary of Groundwater Analytical Results (Controlled Waters)

Determinand		Conc. Range (µg/l)	Location of Max. Conc.	Ramboll Controlled Waters GAC (µg/l)	No. and Location of Exceedances
Metals					
Boron		<MRL - 83	BH14	2,000	0
Nickel		<MRL - 3	BH12	4	0
Polycyclic Aromatic Hydrocarbons					
Naphthalene		<MRL - 0.4	BH12	2	0
Acenaphthylene		<MRL - 0.01	BH12	0.13	0
Acenaphthene		<MRL - 0.065	BH12	0.38	0
Fluorene		<MRL - 0.028	BH12	0.25	0
Phenanthrene		<MRL - 0.047	BH12	1.3	0
Anthracene		<MRL - 0.009	BH12	0.1	0
Fluoranthene		<MRL - 0.033	BH12	0.0063	3 (BH06, BH12, BH13)
Pyrene		<MRL - 0.027	BH12	0.023	2 (BH06, BH12)
Benzo(a)anthracene		<MRL - 0.018	BH12	0.0012	3 (BH06, BH12, BH13)
Chrysene		<MRL - 0.018	BH12	NC	N/A
Benzo(a)pyrene		<MRL - 0.01	BH12	0.00017	1 (BH12)
Indeno(123cd)pyrene		<MRL - 0.009	BH12	0.00017	1 (BH12)
Benzo(ghi)perylene		<MRL - 0.008	BH12	0.00017	1 (BH12)
Benzo(b)fluoranthene		<MRL - 0.022	BH12	0.00017	1 (BH12)
Benzo(k)fluoranthene		<MRL - 0.009	BH12	0.00017	1 (BH12)
Total Petroleum Hydrocarbons					
Aliphatics	C5-C6	<MRL - 55	SW01	15,000 (B)	0

Determinand		Conc. Range (µg/l)	Location of Max. Conc.	Ramboll Controlled Waters GAC (µg/l)	No. and Location of Exceedances
	C10-C12	<MRL - 51	BH05	300 (B)	0
	C12-C16	<MRL - 120	BH03	300 (B)	0
	C16-C21	<MRL - 300	BH03	10 (A)	3 (BH03, BH08, SW01)
	C21-C35	<MRL - 90	BH03	10 (A)	1 (BH03)
Aromatics	C10-C12	<MRL - 56	BH12	90 (B)	0
	C12-C16	<MRL - 70	BH12	90 (B)	0
Volatile Organic Compounds					
Chloroform		<MRL - 3	BH06	2.5	1 (BH06)
Benzene		<MRL - 1.5	BH06	10	0
Per- and Polyfluoroalkyl Substances					
PFBA		<MRL - 0.81	BH12	0.1 (C)	2 (BH11, BH12)
PFPeA		<MRL - 4.26	BH12	0.1 (C)	2 (BH11, BH12)
PFHxA		<MRL - 2.49	BH12	0.1 (C)	2 (BH11, BH12)
PFHpA		<MRL - 1.02	BH12	0.1 (C)	2 (BH11, BH12)
PFHxS		<MRL - 0.51	BH12	0.1 (C)	1 (BH12)
PFOA		<MRL - 1.14	BH12	0.1 (C)	2 (BH11, BH12)
6:2 FTS		<MRL - 16.8	BH12	0.1 (C)	1 (BH12)
PFNA		<MRL - 0.16	BH12	0.1 (C)	1 (BH12)
PFOS		<MRL - 1.13	BH12	0.00065	1 (BH12)
8:2 FTS		<MRL - 1.9	BH12	0.1 (C)	1 (BH12)
PFHxDA		<MRL - 0.1	SW01	0.1 (C)	1 (SW01)
Additional Organics					
pH		7.41 - 7.90	BH11	6 - 9	0

Determinand	Conc. Range (µg/l)	Location of Max. Conc.	Ramboll Controlled Waters GAC (µg/l)	No. and Location of Exceedances
Sulphate	10.0 – 86.6	BH06	400,000	0
Ammoniacal Nitrogen	<MRL – 140	BH12	600	0
Cyanide	<MRL – 20	BH09	50 (A)	0

Notes:

Environmental Quality Standards (EQS) based on Priority Substances (Directive 2008/105/EC) daughter directive of the Water Framework Directive (WFD) (2000/60/EC) Annex VIII. In the absence of an EQS the following criteria has been used:

A – UK Drinking Water Standards
 B – World Health Organisation (WHO): Petroleum Products in Drinking-water
 C – European drinking water standards
 D – Regional Screening Level for Tapwater (US EPA, April 2009)
 E – Dutch Intervention Values, 2009
 F – EQS for List II substances (non-statutory)

NC – No criteria available
 N/A – Not applicable
 MRL – Method reporting limit

6.3 Discussion of Results

The majority of metals were reported to be below method reporting limits in all samples. All metals and other inorganics were below the relevant assessment criteria for controlled waters.

Exceedances of several PAHs (see Table 6.1) were noted in up to three locations (BH06, BH12, BH13). Elevated concentrations of PAHs in BH06 are likely to be associated with slightly elevated PID readings and visual and olfactory evidence of contamination recorded during drilling. BH12 and BH13 are located in the south of the site, within the former fire training area.

Slight exceedances of several TPH fractions were noted in up to three locations (BH03, BH08, SW01). These locations are spread across the site, and are not associated with known current or historical industrial site uses. Recorded concentrations are not considered to be significantly elevated or indicative of gross contamination.

Six samples of groundwater and one sample of surface water were analysed for a suite of 37 PFAS. At least one PFAS was detected in five of the seven analysed samples. Ten different PFAS were detected in BH12, located adjacent south of the fire training area, each being the highest recorded concentration for each substance. The PFAS, PFOS was detected in BH12 only, at a concentration of 1.13µg/l, which exceeds the Environmental Quality Standard (EQS) of 0.00065µg/l (which is also below the laboratory MRL of 0.05µg/l).

In the absence of EQS for other PFAS, European drinking water standards have been applied to PFAS concentrations recorded in groundwater. Whilst overly conservative, given that there are no on-site or adjacent drinking water abstractions, assessment criteria of 0.1µg/l of any single PFAS or 0.5µg/l of total PFAS has been applied. Consequently, all locations where PFAS has been detected exceed the European drinking water standards.

The PFAS, PFHxDA was detected in the sample of surface water (SW01) collected from the drainage channel adjacent south of the site at a concentration of 0.1µg/l. However, this compound was not detected in groundwater on-site. This either indicates an alternative source of PFHxDA; or the compound has been produced as a consequence of the breakdown of other PFAS compounds encountered on-site in groundwater.

Based on the water level in the drainage channel, it is assumed to be in hydraulic continuity with groundwater at the site; and the calculated groundwater flow direction at the site is to the south, towards the drainage channel. Further assessment of the relationship between surface water in the drainage channel and groundwater is recommended to establish whether groundwater migration off-site to the channel is occurring (see Section 9.2).

7. BUILT ENVIRONMENT ASSESSMENT

7.1 Assessment Approach

Ground gases can be produced as a result of the decomposition of organic materials and may also originate from natural sources, such as coal seams and organic-rich soils. The principal components of ground gas are methane and carbon dioxide, although other gases may be present in trace concentrations. Ground gas can present a hazard to site occupants and property as result of flammable / explosive hazards, physiological effects, odour and effects on vegetation.

The ground gas assessment included in this report is provided for indicative purposes only and is not intended for use as a detailed ground gas risk assessment.

Ramboll has applied a semi-quantitative method in line with current good practice guidance on risk assessment to assess ground gas risks. Full details of Ramboll's assessment methodology are presented in Appendix 4.

7.2 Ground Gas Monitoring Results

Specific potential sources of gas generation have not been identified at the site; however, in order to characterise the ground gas regime, three monitoring rounds were carried out between 7th and 20th April 2022. The number and frequency of monitoring rounds was based on guidance provided within CIRIA C655³ for a low sensitivity development and low to moderate gas generation potential. In total eleven wells were monitored which predominately targeted the Made Ground and shallow soils.

A summary of the ground gas concentrations recorded over the three monitoring rounds is provided in Table 7.1 below. The ground gas monitoring results are provided in full in Appendix 3.

Table 7.1: Summary of Ground Gas Monitoring Results

Monitoring Well	Response Zone	Date	Steady State Flow Rate (l/hr)	Methane (% v/v)	Methane Gas Screening Value (l/hr)	Carbon Dioxide (%)	Carbon Dioxide Gas Screening Value (l/hr)
BH01	Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	0.1	<0.1	0.0001	0.1	0.0001
		20/04/2022	<0.1	<0.1	0.0001	0.6	0.0006
BH01(S)	Clay subsoil	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	<0.1	<0.1	0.0001	0.5	0.0005
		20/04/2022	<0.1	<0.1	0.0001	0.8	0.0008
BH03	Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	<0.1	<0.1	0.0001	0.6	0.0006
		20/04/2022	<0.1	<0.1	0.0001	0.6	0.0006
BH03(S)	Clay subsoil	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		20/04/2022	<0.1	<0.1	0.0001	0.1	0.0001

³ Assessing risks posed by hazardous ground gases to buildings; CIRIA C665, 2007

NORTH OF BRO TATHAN BUSINESS PARK, ST ATHAN, BARRY

Monitoring Well	Response Zone	Date	Steady State Flow Rate (l/hr)	Methane (% v/v)	Methane Gas Screening Value (l/hr)	Carbon Dioxide (%)	Carbon Dioxide Gas Screening Value (l/hr)
BH04	Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	0.5	<0.1	0.0005	0.7	0.0035
		20/04/2022	<0.1	<0.1	0.0001	0.7	0.0007
BH05	Limestone bedrock	07/04/2022	0.7	<0.1	0.0007	<0.1	0.0007
		13/04/2022	0.1	<0.1	0.0001	<0.1	0.0001
		20/04/2022	<0.1	<0.1	0.0001	0.4	0.0004
BH05(S)	Made Ground	07/04/2022	<0.1	2.1	0.0021	0.6	0.0006
		13/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		20/04/2022	<0.1	2.4	0.0024	0.9	0.0009
BH06	Clay subsoil / Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	0.5	0.0005
		13/04/2022	<0.1	<0.1	0.0001	0.5	0.0005
		20/04/2022	<0.1	<0.1	0.0001	0.9	0.0005
BH08	Clay subsoil / Limestone bedrock	07/04/2022	0.9	<0.1	0.0009	5.6	0.0504
		13/04/2022	<0.1	<0.1	0.0001	2.7	0.0027
		20/04/2022	<0.1	<0.1	0.0001	5.5	0.0055
BH09	Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	0.4	0.0004
		13/04/2022	<0.1	<0.1	0.0001	0.5	0.0005
		20/04/2022	<0.1	<0.1	0.0001	0.7	0.0007
BH11	Clay subsoil / Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	<0.1	<0.1	0.0001	0.7	0.0007
		20/04/2022	<0.1	<0.1	0.0001	0.8	0.0008
BH12	Limestone bedrock	07/04/2022	2	<0.1	0.0020	<0.1	0.0020
		13/04/2022	0.4	<0.1	0.0004	0.9	0.0036
		20/04/2022	<0.1	<0.1	0.0001	0.8	0.0008
BH13	Clay subsoil / Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	0.9	0.0009
		13/04/2022	<0.1	<0.1	0.0001	1.6	0.0016
		20/04/2022	<0.1	<0.1	0.0001	1.7	0.0017
BH14	Clay subsoil / Limestone bedrock	07/04/2022	<0.1	<0.1	0.0001	<0.1	0.0001
		13/04/2022	<0.1	<0.1	0.0001	0.2	0.0002
		20/04/2022	<0.1	<0.1	0.0001	0.5	0.0005

Some wells (BH01, BH03, BH04, BH05) were installed primarily as groundwater wells to target the underlying Porthkerry Member bedrock and on each monitoring occasion the water level was recorded to be above the response zone (i.e. the well was flooded); therefore, the ground gas results collected from this well have been discounted in the assessment below.

1.1.1 Atmospheric Pressure

Round 1 was undertaken under low atmospheric pressure conditions (992mb) whereas Rounds 2 and 3 were conducted under high atmospheric pressure (1015mb and 1017mb). During Round 1, the atmospheric pressure was recorded as falling in the 24 hours prior to the monitoring.

7.2.1 Flow Rates

The steady state gas flow rates were typically recorded below the instrument detection level (<0.1 l/h) at the majority of well locations, with the exception of a slight flow recorded in BH01 (0.1l/h), BH05 (up to 0.7l/hr), and BH08 (0.9l/hr). A steady state gas flow was recorded at BH12 during Round 1 (2l/hr) and Round 2 (0.4l/hr).

Peak gas flow rates were also recorded during the monitoring rounds. These exceeded the steady state flow at certain locations (a maximum of 1.3 l/h recorded at WS01 during Round 4).

The very low to negligible flow rates recorded over the six monitoring rounds do not indicate that large volumes of ground gases are present at the site.

7.2.2 Methane and Carbon Dioxide

Methane was not recorded above the lower instrument detection limit (<0.1%) in the majority of monitoring wells. However, methane was recorded at low concentrations in BH12 (2.1% and 2.4 % v/v) during Rounds 1 and 3 respectively.

Carbon dioxide concentrations were typically recorded between <0.1% and 1.7% by volume (v/v). Concentrations of carbon dioxide were recorded slightly above 5% from the well located in the north-east of the site, at BH08 (max. of 5.6% v/v during Round 1).

These slightly more elevated carbon dioxide concentrations are considered likely to be associated with a greater thickness of Made Ground, comprising reworked natural materials, recorded as being present in this area of the site. Based on current proposed development proposals for the site, excavation during levelling works is anticipated in this area.

7.2.3 Oxygen

Oxygen concentrations varied from 3.8% v/v in BH05(S) (centre-south of the site) and 21.2% v/v, also in BH05(s). Depleted oxygen concentrations were recorded here on two of the three monitoring rounds. Oxygen levels were recorded to be below 18% by volume in six out of fourteen monitoring wells which targeted the Made Ground, indicating depleted oxygen concentrations in the shallow ground.

Depleted oxygen concentrations were recorded during the first and third monitoring rounds with slightly higher concentrations recorded during the second round. The lowest oxygen levels generally correspond with the highest recorded methane and carbon dioxide concentrations and is likely to be a result of the carbon dioxide and methane concentrations displacing the oxygen.

7.2.4 Carbon Monoxide

Carbon monoxide was detected at concentrations above the lower instrument detection limit (<1 ppm) at three locations BH04 (26ppm), BH05(S) (10ppm), and BH12 (73ppm).

7.2.5 Hydrogen Sulphide

Hydrogen sulphide was not detected at concentrations above the lower instrument detection limit (<10 ppm at all locations).

7.2.6 Volatile Organic Compounds (VOCs)

During the ground gas monitoring a photo-ionisation detector (PID) was used to screen for the potential presence of VOCs within the monitoring wells. Readings above instrument detection were recorded in the majority of the monitoring locations at concentrations of between 0.1ppm and 10.2ppm (BH06). Elevated PID readings were recorded during drilling of BH06 at depths of between 2.10m and 2.90m bgl, associated with black staining and a moderate to strong hydrocarbon odour.

7.3 Classification of Ground Gases

Details of Ramboll's assessment methodology is presented in Appendix 3 and a discussion of the results is provided below.

The carbon dioxide GSV ranged between 0.0001l/h and 0.0504l/h (BH08). All GSVs correspond to 'Characteristic Situation 1' (CS1, very low hazard) in BS8485 which is applicable for industrial/commercial development.

The methane GSV ranged between 0.0001l/h and 0.0024l/h (BH05(S)). All GSVs correspond to 'Characteristic Situation 1' (CS1, very low hazard) in BS8485 which is applicable for industrial/commercial development.

BS8485 indicates that where carbon dioxide typically is greater than 5%, consideration should be given to increasing the classification from CS1 to CS2, where gas protection measures would be required.

Carbon dioxide concentrations slightly above 5% have been recorded in BH08 during one or more of the monitoring rounds. These slightly elevated concentrations are considered likely to be associated with a greater thickness of Made Ground recorded at this location, comprising reworked natural materials. Only very low borehole flow rates were recorded indicating that only limited volumes of ground gas are being generated.

Methane concentrations slightly above 1% have been recorded in BH05(S) during one or more of the monitoring rounds. This monitoring well is installed within Made Ground, comprising reworked natural materials. Borehole flow rates were below the instruments limit of detection, indicating that only limited volumes of ground gas are being generated.

In summary, the majority of the site is considered to be CS1 (very low hazard). Given that only limited volumes of ground gas have been encountered; slightly higher concentrations of carbon dioxide and methane have been identified in a limited number of boreholes; and the proposed development involves earthworks to level the site, Ramboll considers that the CS1 Classification is appropriate for the entire site.

The requirement (or otherwise) and design of any gas protection measures will need to be agreed in consultation with the Local Authority Building Control prior to construction and implemented in line with guidance provided in BS8485 which include consideration for the building's construction and use.

7.4 Workplace Exposure Limit Assessment

In order to confirm if a potential risk to future construction workers exists whilst working in confined spaces, the gas monitoring results for carbon dioxide, carbon monoxide and hydrogen sulphide have been assessed against the short term and long term workplace exposure limits as indicated by the Health and Safety Executive in Workplace Exposure Limits HSE EH40/2005. The results of this assessment are summarised in Table 7.2 below:

Table 7.2: Workplace Exposure Limit Assessment

Substance	Long Term Workplace Exposure Limit (8-Hour TWA Reference Period - ppm)	Short Term Workplace Exposure Limit (15-minute reference period - ppm)	No. of Wells with Long Term Exceedances	No. of Wells with Short Term Exceedances	Peak Concentration
Carbon Monoxide	30	200	1	0	73ppm
Hydrogen Sulphide	5	10	0	0	<10ppm
Carbon Dioxide	5000 (0.5%)	15000 (1.5%)	11	2	5.6%

The short and long-term workplace exposure limits for measured concentrations of hydrogen sulphide were not exceeded.

The long-term workplace exposure limit for measured concentrations of carbon monoxide was exceeded in one location, on one occasion.

The carbon dioxide concentrations from the majority of wells installed in the Made Ground and shallow soil exceed the short-term term workplace exposure assessment limit. The short-term exposure limit is only exceeded in two locations, associated with Made Ground.

Methane concentrations were also recorded below the lower explosive limit (LEL) of 5%.

Exceedance of the workplace exposure limits and depleted oxygen represent a risk to construction workers within confined spaces such as excavations and appropriate mitigation measures should be adopted during future ground works.

The workplace exposure limits apply to exposure from inhalation and the assessment is applicable to construction and maintenance workers within confined spaces including excavations.

7.5 Water Supply Pipes

Buried water supply pipes can be at risk from permeation and accelerated deterioration from certain contaminants. A detailed assessment of existing and future pipe materials is outside of the scope of this investigation; however, architects and designers should liaise with the local water supply company and are directed to the following document for guidance:

- Water UK, Contaminated Land Assessment Guidance, 2014
- Guidance for the Selection of Water Supply Pipes to be used in Brownfield sites; UK Water Industry Research (UK WIR), 2010 (Ref. 10/WM/03/21)

7.6 Building Materials

There are a number of contaminants that may attack some building materials under certain conditions if present. The focus of this investigation is to assess risks to human health and environmental receptors and no assessment has been made of impact to building materials. Further discussion of risk of chemical attack on building materials is provided within Ramboll's Ground Investigation Report.

7.7 Radon

As identified in Ramboll's Phase I ESA, the site lies in a "High Probability Radon Affected Area" as defined by Public Health Wales (i.e. an area where between 10% and 30% of residential properties are projected to contain radon above the residential action threshold). Under Health and Safety legislation, employers have a duty to manage workplace risks including the potential for radon exposure. Health and Safety Executive guidance recommends radon monitoring for workplaces located in radon Affected Areas. If the workplace radon threshold is exceeded, the Ionising Radiations Regulations 1999 require employers to take action to reduce risks.

According to BRE Report BR211 (2015) Radon: Protective Measures for New Buildings, radon protection measures are required under building regulations for new buildings at this location.

If good standards of design and workmanship are applied to the provision of the damp-proof barrier to the floor and walls, adequate protection from radon will be provided along with the general function of excluding moisture. However, in areas with higher radon emission the additional measures will be required.

The requirement (or otherwise) and design of any radon protection measures will need to be agreed in consultation with the Local Authority Building Control prior to construction.

8. SOURCE-PATHWAY-RECEPTOR RISK ASSESSMENT

8.1 Revised Conceptual Site Model

Using information obtained during this site investigation, the preliminary conceptual site model presented in Section 3.1 has been refined and is described in Table 8.1 below.

Table 8.1: Revised Conceptual Site Model

<p>Sources of Contamination</p> <p>On the basis of this site investigation, the following contaminants have been identified at elevated concentrations on site within soils and groundwater:</p> <p>Localised black staining, hydrocarbon odour, and elevated PID readings in the Porthkerry Member limestone bedrock (mudstone bands);</p> <p>Localised slightly elevated concentrations of PAHs and TPH in groundwater; and</p> <p>PFAS in soil and groundwater exceeding assessment criteria.</p>			
<p>Geology</p> <p>Made Ground is locally present, predominantly as reworked natural materials of clay with cobbles of limestone, to depths of up to 2.65m bgl (where proven). Natural ground (subsoil) is present across the site as firm to very stiff grey-brown mottled orange clay with limestone gravel to 3.75m bgl (where proven). The Porthkerry Member, limestone bedrock with bands of mudstone, was proven to depths of 10.00m bgl.</p> <p>Encountered geology is consistent with published records.</p>			
<p>Hydrogeology</p> <p>Groundwater was encountered in all eleven wells at resting levels of between 41.73m and 39.93m AOD, declining from the north-west to the south-east, in line with surrounding topography and towards a drainage channel adjacent to the southern site boundary.</p> <p>The bedrock underlying the site is classified as a Secondary A Aquifer. The site is not situated in a Natural Resources Wales (NRW) designated source protection zone (SPZ). There are no groundwater abstractions for public water supply recorded in environmental database records within a 2km radius of the site. Overall the site is considered to be of moderate environmental sensitivity in terms of groundwater.</p>			
<p>Hydrology</p> <p>A drainage channel was identified at the southern site boundary that appears, from measured resting groundwater levels, to be in hydraulic continuity with groundwater beneath the site. The drainage channel is considered to be downgradient of the site.</p> <p>On site drainage channels flow in a broadly south-westerly direction towards Boverton Brook, located approximately 170m south-west of the site. There are two watercourses within 2km of the site classified by NRW under the Water Framework Directive. There are no surface water abstractions within 2km of the site.</p> <p>According to the NRW fluvial and tidal flood map for planning, the site is located entirely in Zone A; and therefore has little to no flood risk from rivers, sea, reservoirs or dams. There are no known records of historic flooding at Bro Tathan Business Park.</p> <p>There are areas of High, Medium and Low risk of surface water flooding in the west of the site. There are flood bunds in place for attenuation of this surface water, however the proposed development has reconfigured the flood attenuation bunds on site to ensure suitable space for the development as well storage of water. The impermeable area of the site will also increase as part of the development, and therefore surface water runoff will increase.</p> <p>Overall the site is considered to be of moderate environmental sensitivity in terms of surface water.</p>			
<p>Potential Contaminant Linkages</p> <p>The following potential pollutant linkages have been identified at the site and are considered further in the qualitative risk assessment:</p>			<p>Potential Contaminant Linkage</p>
<p>Human Health</p>	<p>On-site</p>	<p>Dermal contact & ingestion</p>	<p>PCL1</p>

(Future Site Users and Construction workers)		Inhalation – dust and asbestos fibres	PCL2
		Inhalation – volatile organic compounds	PCL3
Water Environment	On-site	Leaching of contaminants from the unsaturated zone to groundwater	PCL4
	Off-site	Migration of contaminated groundwater to off-site watercourses	PCL5
Ecological Receptors	On-site	Although there are no statutory designated ecologically sensitive sites present on-site; currently on-going ecology surveys have confirmed the presence of amphibians and waterfowl, within the water feature habitats on-site. Other potential species are also present. Burrowing species such as rabbits, foxes and badgers could also be receptors to contaminants in soil (if present).	PCL6
	Off-site	Species in off-site watercourse habitats could be affected by contamination identified on site (specifically PFAS, if found to be migrating off-site).	PCL7
Built Environment	On-site	Generation of ground gases originating from biodegradable material or contaminants in Made Ground.	PCL8
		Migration of Radon gas into buildings and structures	PCL9

8.2 Qualitative Risk Assessment

The principal sources of contamination, receptors and potential pollutant linkages have been assessed using a qualitative source-pathway-receptor approach and are summarised in Table 8.2 below.

Table 8.2: Qualitative Risk Assessment – Commercial / Industrial Site Use

Potential Contaminant Linkage	Contaminant	Pathways	Receptors	Discussion	Risk Rating
PCL1	Made Ground; and localised black staining, hydrocarbon odour, and elevated PID readings in the Porthkerry Member bedrock	Dermal Contact, Ingestion	Future site Users	<p>Future Commercial / Industrial Site Users</p> <p>Black staining and a moderate to strong hydrocarbon odour were noted in a single location at the centre of the site, within mudstone bands of the Porthkerry Member bedrock. Concentrations of organic compounds were not recorded in excess of the Ramboll GAC for commercial / industrial use at this location; and no current or historical potentially contaminative site uses have been identified in the immediate vicinity. Field observations of contamination were made at a significant depth below ground level (between 2.10m and 2.90m bgl); therefore, sufficiently separated from future site users by depth. No field evidence of contamination was observed above or below these depths at this location, indicating that gross or widespread contamination is unlikely.</p> <p><i>Although PFAS compounds were detected in Made Ground, the concentrations were not found to exceed human health screening criteria (where available). Furthermore, considering the proposed site use as a data centre, there are minimal feasible pathways for dermal contact and ingestion by site users. The exception being landscape workers; however, this risk can be mitigated through the use of appropriate PPE.</i></p> <p>Made Ground is present at the site as a thin, discontinuous layer. Elevated concentrations of contaminants have not been identified in Made Ground and it is considered suitable for use beneath roadways and hard surfaced areas.</p>	Low, assuming appropriate re-use of Made Ground materials
				<p>Construction workers</p> <p>On the basis of the chemical analysis, the risk to construction workers from soil is low. However, precautionary control measures, such as basic personal protective equipment and good hygiene practices should be maintained.</p>	Low, assuming the use of appropriate hygiene measures

Potential Contaminant Linkage	Contaminant	Pathways	Receptors	Discussion	Risk Rating
PCL2 & PLC3	Made Ground; and localised black staining, hydrocarbon odour, and elevated PID readings in the Porthkerry Member bedrock	Inhalation – dust and asbestos fibres	Future site Users	<p>Future Commercial/ Industrial Site Users</p> <p>Asbestos was identified in one of the analysed samples during the ground investigation. Whilst widespread presence of asbestos has not been identified, the presence of asbestos containing materials (ACMs) cannot be discounted based on a number of stockpiles of demolition rubble identified at the site. If during development, further ACMs are encountered, quantification analysis would be required to establish whether soils could remain on-site under hardstanding or require off-site disposal.</p> <p>Whilst elevated PID readings were recorded within mudstone bands of the Porthkerry Member bedrock, they were noted at significant depth; and there were no exceedances of Ramboll GAC for any volatile organic compounds for commercial / industrial site use.</p> <p><i>Although PFAS compounds were detected in Made Ground, the concentrations were not found to exceed human health screening criteria (where available).</i></p>	Low, assuming appropriate re-use of Made Ground materials
				<p>Construction Workers</p> <p>The use of appropriate risk assessment and working procedures, such as PPE where necessary (usually incorporated into the Construction Environment Management Plan (CEMP) will mitigate risks to workers.</p>	Low, assuming the use of appropriate control measures

Potential Contaminant Linkage	Contaminant	Pathways	Receptors	Discussion	Risk Rating
PCL4	PFAS in shallow soil; and localised black staining, hydrocarbon odour, and elevated PID readings in the Porthkerry Member bedrock	Leaching of contaminants in unsaturated zone	Groundwater in the underlying bedrock	<p>Slightly elevated concentrations of PAH and VOC were identified in groundwater associated with observations of black staining and a moderate to strong hydrocarbon odour at the centre of the site. Four PAH and one VOC were recorded at concentrations exceeding respective GAC for Controlled Waters. However, exceedances are marginal, and are not indicative of a significant ongoing source of groundwater contamination associated with the field observations of contamination in bedrock.</p> <p>Slightly elevated concentrations of PAH were also recorded in groundwater in the south of the site, in the former fire training area.</p> <p>PFAS were identified in seven out of fifteen analysed samples of shallow soil at relatively low concentrations (not exceeding the available assessment criteria), predominantly located in and around the fire training area. Elevated concentrations of PFAS (exceeding the drinking water standards used as assessment criteria) were also identified in groundwater in this area, potentially associated with leaching from soil. Whilst fire training activities have ceased at the site (considered to be the most likely source of PFAS contamination), PFAS in soil may continue to act as a potential source of PFAS contamination to groundwater through leaching.</p> <p>Given that there are no groundwater abstractions for public water supply recorded within a 2km radius of the site, the use of drinking water standards as assessment criteria is a conservative approach.</p>	High – PFAS has been identified in soil and groundwater on-site with potential to leach further into groundwater

Potential Contaminant Linkage	Contaminant	Pathways	Receptors	Discussion	Risk Rating
PCL5	PAH, VOC, and PFAS identified in groundwater	Lateral migration via groundwater	Groundwater in the underlying bedrock and surrounding surface waters	<p>Groundwater beneath the site is classified as a Secondary A Aquifer; and is not in a designated source protection zone (SPZ), nor are there abstractions for public water supply within a 2km radius of the site. Groundwater flow direction is from the north-west to the south-east, in line with surrounding topography and towards a drainage channel adjacent to the southern site boundary.</p> <p>Localised, slight exceedances of the GAC for Controlled Waters were recorded for PAH and VOC in groundwater. Whilst groundwater at the site is understood to form a continuous aquifer that extends beneath (and off) the site, identified exceedances are marginal and are not indicative of gross or widespread groundwater contamination. Furthermore, PAH were not detected in the surface water sample collected from a drainage channel adjacent south of the site, which is considered to be downgradient and in hydraulic continuity with groundwater at the site.</p> <p>Similarly for PFAS, elevated concentrations were identified in groundwater at the site, at concentrations exceeding the adopted screening criteria.</p>	High – the potential for off-site migration of PFAS in groundwater cannot be ruled out
PCL6 & PCL7	PFAS	Migration in groundwater to surface water in hydraulic continuity Ingestion of soil	Ecological - several species & their habitats	<p>PFAS compounds have been identified in soil and groundwater on-site. The compounds are known to bioaccumulate and there is potential for the habitats on-site to be impacted, specifically the surface water features (both on-site and immediately adjacent). Current on-going ecology surveys have confirmed the presence of amphibians and waterfowl, within the water feature habitats on-site. Other potential species are also present.</p> <p>Burrowing species such as rabbits, foxes and badgers could also be receptors to contaminants in soil.</p>	Moderate
PCL8	Ground gases	Lateral and vertical migration	Future site Users and Built Environment	Results of three rounds of ground-gas monitoring indicate the site to be Characteristic Situation (CS) 1: very low risk. Based on this assessment, no specific gas protection measures are considered to be warranted. Given the nature of the underlying ground conditions, the generation of significant ground-gas concentrations is unlikely.	Low

Potential Contaminant Linkage	Contaminant	Pathways	Receptors	Discussion	Risk Rating
PCL9	Radon	Lateral and vertical migration	Future site Users and Built Environment	<p>The site lies in a "High Probability Radon Affected Area" as defined by Public Health Wales (i.e. an area where between 10% and 30% of residential properties are projected to contain radon above the residential action threshold).</p> <p>According to BRE Report BR211 (2015) Radon: Protective Measures for New Buildings, radon protection measures are required under building regulations for new buildings at this location.</p>	Low, assuming appropriate radon protection measures are installed

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The Phase II ESA forms part of a geo-environmental ground investigation, comprising 14 boreholes to depths of up to 10.0m bgl and 28 trial pits to depths of 3.1m bgl, designed to investigate the depth to and integrity of shallow limestone bedrock; test geotechnical properties; and to target the potential historic contamination sources identified at the site, specifically the fire training ground in the south. Geotechnical elements are reported separately.

9.1.1 Ground Conditions Encountered

Made Ground is locally present, predominantly as reworked clay with cobbles of limestone, to depths of up to 2.65m bgl (where proven). Natural ground (subsoil) is present across the site as firm to very stiff grey-brown mottled orange clay with limestone gravel to 3.75m bgl (where proven). The Porthkerry Member, limestone bedrock with bands of mudstone, was proven to depths of 10.0m bgl. Encountered geology is consistent with published records.

Groundwater was encountered in all eleven wells, with resting levels declining from the north-west to the south-east, in line with surrounding topography and towards a drainage channel adjacent to the southern site boundary.

Black staining and a hydrocarbon odour were noted in BH06, within thin beds of very weak mudstone. Field evidence of contamination was not observed at shallower or deeper depths at this location. There are no potential sources of contamination identified in current or historical use of the site at this location. The observation coincides with groundwater exceedances of Controlled Water screening criteria for several PAH compounds; however, it is noted that soil analysis at the same location did not identify exceedances of human health screening criteria. The exceedances were not significant and Ramboll considers the contamination to be localised in vertical and lateral extent. No free phase hydrocarbons were detected in groundwater across the site.

9.1.2 Risks to Human Health

Whilst localised field evidence of contamination (black staining and hydrocarbon odour) was recorded during the investigation, concentrations of contaminants in excess of the Ramboll GAC for commercial / industrial use have not been detected in samples of soil. Field evidence of contamination was not observed at other depths at this location, or at nearby exploratory locations, indicating that gross or widespread contamination is unlikely.

Asbestos was detected in one of the twenty-nine analysed samples of soil. Whilst widespread presence of asbestos has not been identified during the investigation, there is potential for undiscovered asbestos containing material to be present at the site, particularly associated with the stockpiles of demolition rubble.

PFAS were detected in eight out of fifteen analysed samples of shallow soil. PFAS in soil was primarily detected in the vicinity of the fire training area in the south of the site; however, it is noted that PFAS analysis was concentrated in this area. Whilst there are no available assessment criteria for PFAS for human health in a commercial / industrial setting, EA Soil Screening Values (SSVs) for PFOA and PFAS have not been exceeded by analysed samples of soil from this investigation. Overall, the risks to human health from PFAS are considered to be low, due to the absence of a pollutant linkage or pathway. E.g. groundwater is not abstracted for drinking water in the vicinity; and PFAS do not volatilise therefore mitigating the potential for inhalation.

No groundwater concentrations were detected exceeding the human health pathway for groundwater volatilisation for a commercial / industrial end use (where available).

Slightly elevated concentrations of ground gases carbon dioxide (above 5%) and methane (above 1%) have been recorded during one or more of the monitoring rounds; however, only very low borehole flow rates were recorded, indicating that only limited volumes of ground gas are being generated.

The majority of the site is considered to be 'Characteristic Situation 1' (CS1, very low hazard) in BS8485 which is applicable for industrial/commercial development. Based on this assessment, no specific gas protection measures are considered to be warranted. However, the requirement (or otherwise) and design of any gas protection measures will need to be agreed in consultation with the Local Authority Building Control prior to construction.

The site lies in a "High Probability Radon Affected Area" as defined by Public Health Wales (i.e. an area where between 10% and 30% of residential properties are projected to contain radon above the residential action threshold). According to BRE Report BR211 (2015) Radon: Protective Measures for New Buildings, radon protection measures are required under building regulations for new buildings at this location. The requirement (or otherwise) and design of any radon protection measures will need to be agreed in consultation with the Local Authority Building Control prior to construction.

9.1.3 Risks to Controlled Waters

Slightly elevated concentrations of PAHs and VOCs were identified in groundwater associated with observations of black staining and a moderate to strong hydrocarbon odour at the centre of the site. Four PAHs and one VOC were recorded at concentrations exceeding respective GAC for Controlled Waters. However, exceedances are marginal, and are not indicative of a significant ongoing source of groundwater contamination. Slightly elevated concentrations of PAH were also recorded in groundwater in the south of the site, in the former fire training area.

Slight exceedances of several TPH fractions were noted in three locations, spread across the site, that are not associated with known current or historical industrial site uses. Recorded concentrations are not considered to be significantly elevated or indicative of gross contamination.

Whilst groundwater at the site is understood to form a continuous aquifer that extends beneath (and off) the site, identified exceedances are marginal and are not indicative of gross or widespread groundwater contamination. Furthermore, PAHs were not detected in the surface water sample collected from a drainage channel adjacent south of the site, which is considered to be downgradient and is likely to be in hydraulic continuity with groundwater at the site.

PFAS was detected in five of the seven analysed water samples (six groundwater and one surface water). Maximum concentrations were generally recorded in BH12, located adjacent south of the fire training area (including detection of PFOS, which exceeds the Environmental Quality Standard (EQS)). In the absence of EQS for other PFAS, European drinking water standards were applied to PFAS concentrations recorded in groundwater, which is considered to be a conservative approach given that there are no on-site or adjacent drinking water abstractions. Consequently, all locations where PFAS has been detected exceed the adopted screening criteria.

The PFAS, PFHxDA was detected at a very low concentration in the sample of surface water (SW01) collected from the drainage channel adjacent south of the site. This compound was not detected in groundwater on-site. This either indicates an alternative source of PFHxDA; or the compound has been produced as a consequence of the breakdown of other PFAS compounds encountered on-site in groundwater.

Based on the observed water level in the drainage channel, it is assumed to be in hydraulic continuity with groundwater at the site; and the calculated groundwater flow direction at the site

is to the south, towards the drainage channel. Further assessment of the relationship between surface water in the drainage channel and groundwater is recommended to establish whether groundwater migration off-site to the channel is occurring (see Section 9.2).

Whilst fire training activities have ceased at the site (considered to be the most likely source of PFAS contamination), PFAS in soil may continue to act as a potential source of PFAS contamination to groundwater through leaching.

9.1.4 Risks to Ecological Receptors

PFAS compounds are known to bioaccumulate and there is potential for the habitats on-site to be impacted, specifically the surface water features (both on-site and immediately adjacent). On-going ecology surveys have confirmed the presence of amphibians and waterfowl, within the water feature habitats on-site. Other potential species are also present.

Burrowing species such as rabbits, foxes and badgers could also be receptors to contaminants in soil.

9.2 Recommendations

Overall, the localised elevated concentrations of contaminants identified on-site in soil and groundwater are minimal and are considered to present a low risk to receptors, with the exception of PFAS compounds. PFAS have been identified in the fire training area within soil and groundwater. Based on the available results, the fire training area and immediate vicinity appear to be the most impacted. Further delineation of PFAS compounds is required to confirm the extent of impact and therefore to inform a Remediation Strategy.

9.2.1 PFAS Contamination

The following next steps are recommended:

- Sampling and analysis of all boreholes installed at the site for PFAS compounds to delineate the extent of PFAS in groundwater. The analysis would be for a specific suite of PFAS to the lowest available laboratory method reporting limits.
- Installation of additional monitoring points to delineate the PFAS impact in soil and groundwater.
- Surface water and sediment sampling of on-site and off-site drainage channels to establish PFAS impact and whether migration off-site is occurring.
- Groundwater and surface water level monitoring and analysis to confirm whether these are in hydraulic continuity.
- A survey of the drainage network associated with the fire testing area to confirm drainage routes and condition of drainage infrastructure.
- The results of this additional assessment would be used to prepare a Remediation Options Appraisal.

9.2.2 General Recommendations for Site Redevelopment

- A radiological survey has confirmed the presence of several radiological hot spots. The hot spots will need to be removed (excavated) under an Environmental Permit for the accumulation and disposal of radioactive waste issued by NRW. *Ramboll has made a Permit Application on behalf of the Client (April 2022) and the work will be undertaken upon receipt of the Permit.*
- Further investigation of stockpiles containing demolition-type material should be undertaken to determine whether suitable for re-use on-site, or whether off-site disposal is required. Risk

assessments and method statements should be in place to account for the presence of asbestos in the stockpiled material.

- Although a low risk of ground gas generation has been concluded, a further three rounds of monitoring is recommended to satisfy anticipated planning conditions. This could be undertaken during the aforementioned PFAS delineation investigation.
- Implementation of radon protection measures; the requirements (or otherwise) and design of which will need to be agreed in consultation with the Local Authority Building Control.
- It is noted that there is below-ground infrastructure in the vicinity of the fire-fighting training area, likely below ground storage tanks or interceptors and drainage. The excavation of below ground infrastructure will be required, followed by validation sampling to demonstrate that soil and groundwater in the immediate vicinity has not been impacted.
- In accordance with good practice in developing brownfield land, it is recommended that a watching brief is implemented during ground works to identify any unforeseen ground conditions or localised contamination hotspots (e.g. concentrated pockets of ash, asbestos or hydrocarbons), especially during the removal of stockpiles.

APPENDIX 1 FIGURES

APPENDIX 2 EXPLORATORY HOLE LOGS

APPENDIX 3 FIELD MONITORING RESULTS

**APPENDIX 4
LEGISLATIVE BACKGROUND AND DERIVATION OF ASSESSMENT
CRITERIA**

LEGISLATIVE BACKGROUND

The regime for contaminated land was set out in Part 2A (ss.78A-78YC) of the Environmental Protection Act 1990 (EPA), as inserted by S.57 of The Environment Act 1995 and came into effect in Wales on 1st July 2001 as The Contaminated Land (Wales) Regulations 2001 (WSI 2001/2197, W.157). These regulations were subsequently revoked with the provision of The Contaminated Land (Wales) Regulations 2006 (SI 2006/2989 W.278), which consolidated the previous regulations and amendments and added in provisions regarding radioactive contaminated land. These regulations came into force on 10th December 2006 and were accompanied by statutory guidance published by the Welsh Assembly Government in December 2006 ('the Guidance') for local authorities on how to implement the regime. The 2006 statutory guidance was replaced by the Contaminated Land Statutory Guidance - 2012 (WG19243), issued by the Welsh Government.

Under Part 2A of the EPA Section 78A(2), "contaminated land" is defined as "land which appears... to be in such a condition, by reason of substances in, on or under the land, that:

- a) significant harm is being caused or there is a significant possibility of such harm being caused; or
- b) pollution of controlled waters is being or is likely to be caused"⁴.

"Significant harm" is defined in the Guidance on risk-based criteria and must be the result of one or more relevant 'contaminant linkages' relating to the land. The presence of a contaminant linkage relies on the Source-Pathway-Receptor concept, where all three factors must be present and potentially or actually linked for a potential risk to exist. Under the Guidance, a 'significant contaminant linkage' is one which gives rise to a level of risk sufficient to justify a piece of land being determined as contaminated land. Should the authority consider that there is an unacceptably high probability, supported by robust science-based evidence that significant harm would occur if no action is taken to stop it, the land should be deemed a Category 1: Human Health.

Land should be placed into Category 2 if the authority concludes, on the basis that there is a strong case for considering that the risks from the land are of sufficient concern, that the land poses a significant possibility of significant harm.

Both Category 1 and Category 2 cases would be capable of being determined as contaminated land under Part 2A on the grounds of significant possibility of significant harm to human health. If the legal test for significant possibility of significant harm is not met, the authority should place the land into Category 3. If the local authority considers that there is no risk or that the level of risk posed is low, the land should be placed into Category 4.

For six common contaminants (benzo(a)pyrene, cadmium, arsenic, benzene, hexavalent chromium and lead), a set of screening values have been developed and endorsed for use by Defra⁵ (the Category 4 Screening Levels, or C4SLs) that describe a level of risk just below the Category 3/4 boundary set in the Statutory Guidance, i.e. where concentrations are below the C4SL, there is no risk or the level of risk is acceptably low. In March 2015, the Welsh Government issued a statement reaffirming that C4SLs are a "pragmatic but still strongly precautionary approach to risk assessment of potentially contaminated land". They represent a level of a contaminant in soil that would pose a low risk to human health and would not be considered contaminated under Part 2A. The statement notes that C4SLs have been derived using toxicological methods that are robust and are considered appropriate in the UK. The Welsh

⁴ Section 86 of the Water Act 2003 remains only partially implemented in Wales.

⁵ SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document, Defra, revised December 2014

Government's statement confirms that C4SLs can provide a simple test for deciding if land is suitable for use and definitely not contaminated under Part 2A. As such, they can be used as generic screening criteria and could be used as part of the risk assessment process under the planning regime as with Part 2A.

The pollution of controlled waters is defined in Section 78A(9) of the Act as "the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter". According to the Guidance, before determining that pollution of controlled waters is being, or is likely to be, caused, the local authority should be satisfied that a substance is continuing to enter controlled waters or is likely to enter controlled waters. The term "controlled waters" in relation to Wales has the same meaning as in Part 3 of the Water Resources Act 1991, except that "ground waters" does not include waters contained in underground strata but above the saturation zone.

As with human health risk, Categories 1 and 2 comprise land where the local authority considers that a significant possibility of significant pollution of controlled waters exists and Categories 3 and 4 comprises cases where the authority considers that a significant possibility of such pollution does not exist. The local authority should be satisfied that a substance is continuing to enter controlled waters or is likely to enter controlled waters.

GROUND GAS ASSESSMENT

The assessment of risks from ground gas is based on current best practice guidance provided in the following documents:

- BS8485:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings
- NHBC, 2007. Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present (applicable for low rise residential housing with beam and block flooring and a clear ventilated void)

Where relevant, the risk to workers in confined spaces from ground gases (carbon dioxide, carbon monoxide, hydrogen sulphide) has also been assessed using guidance in the following document:

- Health and Safety Executive Workplace Exposure Limits HSE EH40/2005

Derivation of Characteristic Situation

The risk posed by ground gases using the approaches outlined in the documents above are assessed by calculating a Gas Screening Value (GSV). Derivation of the GSV is calculated by multiplying the steady state borehole flow rate (l/hr) with the peak carbon dioxide and methane concentrations for each well. Where required, a 'worst case' condition is also calculated by multiplying the maximum recorded steady state borehole flow rate with the peak carbon dioxide and methane concentrations for different strata across the entire site or zone (as applicable).

The calculated GSV is used to derive a 'Characteristic Situation' which ranges between CS1 (very low hazard potential) to CS6 (very high hazard potential) as defined within BS8485; or to categorise the site as Red / Amber / Green (referred to as traffic lights) as defined within the NHBC guidance for low rise residential buildings.

Requirement for Gas Protection Measures

Depending on the type of proposed development, the British Standards Characteristic Situation or NHBC traffic light system is used to determine the gas protection measures needed for a building. Gas protection measures are generally not required for CS1 or NHBC Green sites unless the Conceptual Site Model indicates a need for further consideration. Although BS8485 and NHBC guidance relates to assessment for new buildings the same assessment methodology can be applied for appraisal of existing site buildings.

BS8485 requires a gas protection score to be identified for a proposed development. This is categorised based on the 'building type' from Type A to D, based on factors including construction and use of the building, together with the control of future structural changes to the building and its maintenance, since potential risks posed by ground gases are strongly influenced by these factors.

Gas protection measures are selected to meet the required gas protection score in BS8485, although for some developments in higher Characteristic Situations the gas hazard is considered too high to use the method outlined in BS8485 to define the gas protection measures and further detailed quantitative gas risk assessment is required.

For low rise residential developments, the NHBC traffic light system also uses the GSV to derive the minimum level of protection required and expectations for verification for sites classified as either Amber 1 or Amber 2. NHBC considers that standard residential housing sites with a Red classification would not normally be acceptable without a detailed gas assessment and /or possible remediation to reduce or remove the ground gas source.

GENERIC ASSESSMENT CRITERIA

Soils

In accordance with current UK guidance on legislation including Part 2A of the Environmental Protection Act 1990 and based on the principles of risk assessment, Ramboll has derived generic criteria for interpretation of soil and groundwater chemical analysis (Ramboll Generic Assessment Criteria – Ramboll GAC). The assessment of chemical data from an intrusive investigation is undertaken in a tiered approach, and the first stage is a Generic Quantitative Risk Assessment (GQRA). The Ramboll GAC are considered to be threshold-based screening concentrations, at which a significant risk is not considered to be present to the relevant receptors.

The Soil Guideline Values (SGVs) for 11 compounds published in 2009 by the Environment Agency, are based on a sandy loam soil with 6% soil organic matter (SOM). The 6% SOM and sandy loam soil type is not considered by Ramboll to be realistic of 'typical' UK soil conditions, and EA guidance⁶ states that at 6% SOM, SGVs may not be sufficiently protective (i.e. the values are too high to be sufficiently certain that they describe land where there is no risk to human health or the risk is negligible). For the Ramboll GAC, all the SGV inputs have been used with the exception of SOM and soil type, which have been amended to 1% and sand; thereby ensuring a suitably conservative Ramboll GAC appropriate for most soils and Made Ground encountered in the UK. It is noted that none of the screening criteria used in the UK, including the SGVs, have a statutory basis.

The Ramboll GAC for soil assessment are based on the generic scenarios outlined in the Contaminated Land Exposure Assessment (CLEA) methodology and guidance documents, and include inhalation, ingestion, dermal contact of soil and dust as pathways for commercial and residential scenarios; as well as ingestion of homegrown produce for residential with gardens scenario. In addition, Ramboll GAC have also been derived for the two Public Open Space land uses defined in C4SL guidance (outlined below). These have been calculated by use of two proprietary risk assessment models (CLEA Version 1.071 and the ASTM RBCA7 Tool Kit Version 2.6 for Chemical Releases) which have been altered, where necessary, to reflect the current UK approach to human health risk assessment as set out in Land Contamination: Risk Management (LCRM) and the CLEA guidance documents (incorporating Science Reports SC050021/SR2 (January 2009), SR3 (January 2009), SR4 (September 2009) and the SGV reports (2009)). The physiochemical data has been taken from or derived using the methodology detailed in SR7 (November 2008) and SGV reports (2009), where feasible. The toxicology data has been taken from the current published EA toxicology documents.

This approach by Ramboll follows the withdrawal of CLR 7-11, CLEA UK (beta), and CLEA Model versions V1.04 to V1.07 by the Environment Agency and DEFRA. The approach has been applied to all contaminants with the exception of lead and nickel, as the respective SGV has been withdrawn by the Environment Agency.

In the absence of published EA data, reference has been made to further UK published guidance in the first instance.

Reference has been made to the Defra-funded research project (SP1010⁸), which developed a methodology to derive Category 4 Screening Levels (C4SLs) for six contaminants (benzo-a-pyrene, cadmium, arsenic, benzene, hexavalent chromium and lead). SP1010 provides technical

⁶ 'Using Soil Guideline Values' published by the Environment Agency March 2009 SC050021/SGV

⁷ American Society for Testing Materials – Risk Based Corrective Action Model, Version 2.6

⁸ SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination - Final Project Report, Defra, September 2014

tools and advice to be developed to help regulators and others to conform to the requirements of revised Part 2A Statutory Guidance.

Defra's Policy Companion⁹ document to the SP1010 project states that where a C4SL value has been derived for a contaminant where an SGV exists, it is anticipated that risk assessors will use the C4SL value in line with Part 2A Statutory Guidance; this is reaffirmed in the LCRM, which states that where an SGV and a C4SL are available for the same contaminant, the Environment Agency expects risk assessors to use the C4SL with published SGVs used where an alternative has not been developed. In the absence of a suitable C4SL, risk assessors should identify and select appropriate generic assessment criteria in accordance with established good practice. On this basis, Ramboll has adopted the use of C4SLs however minimal risk assumptions have been applied in-house Ramboll GAC for other contaminants of concern within our screening assessments.

Ramboll also attended the Land Quality Management and Chartered Institute of Environmental Health workshop for the collaborative development of 'Suitable 4 Use Levels' (S4ULs) and reference has been made to their publication 'The LQM/CIEH S4ULs for Human Health Risk Assessment, 2015'.

Review of additional UK organisation guidance including Contaminated Land: Applications in Real Environments (CL:AIRE) and partners GAC, including addendums up until 10 April 2012 has also been made. Finally, where necessary, other published sources of (non-UK) information, such as the RBCA V2.6 database have also been reviewed.

Assessment of Impact to Waters

Assessment of risks to water resources is completed in general accordance with guidance provided in the Environment Agency's Approach to groundwater protection (2018¹⁰).

Generic assessment criteria for waters have been selected by Ramboll to assess potential risks to the identified environmental receptors. A hierarchical approach has been taken to the use of assessment criteria based on adoption of published water quality standards at European level and UK specific standards, with those standards being chosen based on the conceptual site model and identified critical receptors. For those determinants included in the analytical suite which do not have a corresponding UK drinking water or environmental screening criteria, reference is made to international guidance in accordance with Environment Agency recommendations.

Where such standards are unavailable, standards taken from other organisations, for example the World Health Organisation or OSPAR, have been used.

The list of critical legislation used in this approach is described below.

European Assessment Criteria:

- 2000/60/EC: Water Framework Directive
- 2006/118/EC: On the Protection of Groundwater Against Pollution and Deterioration
- 2013/39/EU: Priority Substances in the Field of Water Policy Directive

UK Assessment Criteria:

- UKTAG Groundwater Hazardous Substances Standards 2016, annex 2018

English and Welsh Criteria:

- The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017

⁹ SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document, Defra, revised December 2014

¹⁰ The Environment Agency's approach to groundwater protection; February 2018; Version 1.2.

- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- The Groundwater (Water Framework Directive) (England) Direction 2016
- The Water Supply (Miscellaneous Amendments) Regulations (England and Wales) 2010

Other Criteria:

- World Health Organisation (WHO) Drinking Water Regulations 4th edition 2011
- World Health Organisation (WHO): Petroleum Products in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality 2008
- USEPA National Primary Drinking Water Regulations
- OSPAR: Establishment of a List of Predicted No Effect Concentrations (PNECs) for Naturally Occurring Substances in Produced Water. OSPAR Agreement 2014-2015

Minimum reporting values are also considered for hazardous substances for assessment of risks to groundwater resources in order to comply with the requirements of the guidance to 'prevent' input of hazardous substances to groundwater.

Assessment of Water Impact to Human Health

A methodology for the generation of the GAC for groundwater vapours (GACgwwap) was published by the Society of Brownfield Risk Assessment (SoBRA) in February 2017¹¹, which is based on the CLEA model. Ramboll has adopted SoBRA's approach and modified the model input parameters to reflect site conditions and generate site SSAC for groundwater contaminant sources designed to be protective of site users for a residential and/or commercial/industrial scenario as appropriate.

The SoBRA (GACgwwap) methodology uses the Environment Agency's CLEA software model. The CLEA software was originally provided for deriving assessment criteria for soils, not groundwater; however, groundwater assessment criteria can be extracted from the calculations within CLEA. CLEA assumes a steady state equilibrium between the sorbed, water and vapour phase concentrations in soil. Consequently, as part of the process of calculating soil phase concentrations, the software also calculates the vapour phase concentration and the pore water dissolved concentration (soil solution concentration) at the soil GAC. Therefore, for given soil assessment criteria derived to be protective of health, a soil solution concentration is also available within the CLEA calculations which would give rise to this vapour concentration at the tolerable risk level. This soil solution concentration is used as an inferred groundwater SSAC.

The proprietary risk assessment model, the ASTM RBCA¹² Tool Kit Version 2.6 for Chemical Releases, has been used for compounds which could not be run in CLEA. The RBCA model has been altered where necessary to reflect the current UK approach to human health risk assessment, as appropriate.

¹¹ SoBRA (2017) Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater. Version 1.0

¹² American Society for Testing Materials – Risk Based Corrective Action Model, Version 2.6

APPENDIX 5 SOIL ANALYTICAL RESULTS

APPENDIX 6 WATER ANALYTICAL RESULTS