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WREXHAM AFC KOP DEVELOPMENT CONTAMINATED LAND INTERPRETATIVE REPORT

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1. INTRODUCTION

1.1 Brief

- 1.1.1 Ramboll UK Limited (Ramboll) has been instructed by Wrexham Association Football Club (the 'client') to prepare a Generic Quantitative Risk Assessment (GQRA) for the proposed Wrexham AFC Kop Stand Development.
- 1.1.2 The site is located within the eastern part of the existing Wrexham Football Club Racecourse Ground football stadium. The site also includes the four floodlight towers situated in each corner of the stadium. The site is located on Mold Road, close to the A483 dual carriageway and immediately to the northwest of the town centre, between the Wrexham General railway station and the university campus. The approximate centre of the site is at National Grid Reference SJ 32885 50952.
- 1.1.3 This assessment has been undertaken assuming the site will be redeveloped for an end-use comprising a new Kop Stand and new floodlights. A Site Location Plan is provided in Figure 1.
- 1.1.4 The ground investigation detailed in this report was phased as follows:
- Phase I - Floodlights ground investigation including BH100-BH103 and shallow foundation inspection pits IP100 and IP101;
 - Phase II - New Kop Stand ground investigation including boreholes BH104-BH106 and trial pits TP100-TP104 in the footprint of the proposed stand and adjacent public realm area; and
 - An additional ground investigation undertaken by P.P. O'Connor Ltd (Demolition Contractor) comprising trial pits into the mound of material that was situated beneath the old Kop stand¹; and
- 1.1.5 This GQRA is produced with consideration to Tier 2 of Stage 1 (Risk Assessment) of Land Contamination Risk Management (LCRM) published by the Environment Agency (EA) in 2021 and is applicable to developments in Wales. As such, the brief is to present the GQRA objectives, define the scope of investigation, define suitable generic assessment criteria to which results of investigation can be compared, present investigation findings and assessment of results, and update the preliminary conceptual site model for the site which was produced at the Preliminary Risk Assessment (PRA) stage. The conclusions of the GQRA are used to inform what further action is needed.

1.2 Proposed Development

- 1.2.1 The Wrexham Gateway Partnership (Established in 2018) comprises of Welsh Government, Wrexham County Borough Council and Wrexham Glyndŵr University. The Wrexham Gateway project will result in the redevelopment of the site around Wrexham General railway station, as well as improvements to WAFC's Racecourse Ground by creating a new stand at the Kop end under planning application ref: P/2022/0725. New floodlights will also be included as part of the Wrexham Gateway project under a separate live planning application (Planning Ref: P/2022 /0548).
- 1.2.2 The Kop Stand development will include the demolition of the current Kop Stand and construction of a new standing terrace with capacity for up to 5,500 spectators, raising the overall capacity of the stadium to approximately 15,000 for league games. In addition, replacement of the existing floodlights is proposed at four corners of the pitch.
- 1.2.3 The first floor of the new stand will be fitted out with the club offices and community space. The club store will also move to the ground level concourse. Each of those uses will be relocated from

¹ This additional Investigation was undertaken by P.P. Conner Ltd following demolition of the old Kop stand, following a methodology prepared by Ramboll. The investigation was primarily aimed at informing waste disposal options, but the information is included in this report for completeness.

existing stands providing improved accommodation and facilitating wider improvements at the ground.

- 1.2.4 The new stand will also provide new hospitality spaces on the upper level with capacity for up to 500 persons on match days and up to 250 persons (banqueting) on non-match days.
- 1.2.5 From drawings provided to Ramboll (MLD-EX-XX-DR-L-1003 – appended to this report) it is understood the public realm area to the east of the Kop stand will be areas of hard standing with above ground planters and tree pits along the eastern boundary. The current design for the tree pits will require excavations to 950mm below ground level (bgl). Within the public realm area will be CCTV masks with foundation depth of 830mm bgl.
- 1.2.6 The foundations for the new stand will comprise piles constructed utilising the continuous flight auger (CFA) technique currently planned to be to depths of 20m bgl. The section showing the number of piles is shown in drawing WRX-RAM-04-FN-DR-S-10091 (appended to this report). Currently the depth of the piles for the new floodlights are unknown so therefore assumed to be similar to depths proposed for the CFA piles for the new stand.
- 1.2.7 The Kop development's plan for managing surface water drainage involves several drainage systems that work in unison, these are.
 - A siphonic drainage system that directs water from the Kop roof;
 - A network of channel drains collecting water from the external hardstanding;
 - A green roof on the adjacent toilet block; and
 - Permeable paving with subbase storage / infiltration layer to the front of the stand.
- 1.2.8 The water is collected from these systems and piped from the impermeable areas to soakaway locations which take advantage of the sites excellent infiltration characteristics. This strategy aligns with the surface water management hierarchy specified in national planning policies, which prioritizes ground infiltration. While the current design includes geocellular soakaways, future adjustments may replace them with permeable build ups and subbase storage/infiltration layers to better suit the site's logistical requirements.
- 1.2.9 The proposed improvements will enable the Racecourse Ground to be brought up to UEFA Category 4 standards, enabling the stadium to be used for international and Premier League football matches.

1.3 Objectives

- 1.3.1 The objectives of this report build upon the preliminary risk assessment² and consider LCRM; specifically the objectives include:
 - Confirm which potential contaminant linkages identified at PRA stage are to be assessed;
 - Document how the ground investigation was designed to assess those potential contaminant linkages and any constraints on the ground investigation;
 - Document findings of the ground investigation, and interpret the environmental ground conditions encountered during ground investigation;
 - Document details of presence of structures and buried services that could influence the conceptual site model, where these have been identified through the investigation;
 - Establish appropriate generic assessment criteria and a standard set of generic assumptions to assess the risks;
 - Assess the potential for risks to both human health and environmental receptors (including controlled waters) based on the data collected;

² Wrexham AFC Kop Redevelopment Ground Investigation Specification Report (1620012485-RAM-XX-XX-RP-CE-00001)

- 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;
- Identify potential for changes to ground conditions due to weather conditions and seasonal/climatic patterns and how these changes may affect the CSM;
- Provide a commentary on contaminated land risks;
- Provide further recommendations if required;
- Provide preliminary waste classification using a HazWasteOnline assessment;
- Support the discharge of planning conditions relevant to contaminated land; and
- Provide guidance to the earthworks contractor on the management of contaminated soils, including an unexpected contamination procedure and verification plan.

1.4 Planning Conditions

- 1.4.1 The planning conditions relevant to contaminated land under Planning Ref P/2022/0725 for the new Kop development are shown below for reference. It is intended that this report will support the discharge of Planning Condition No. 6 (II, III & IV). Please refer to section 10.4 for details on discharging planning conditions.

Planning Condition No. 6 (Risk of Contamination)

- 1.4.2 No development or phase of development, shall commence until the following components of a scheme to deal with the risks associated with contamination at the site, has been submitted to and approved in writing by the Local Planning Authority.
- I. A preliminary risk assessment which has identified:
 - all previous uses;
 - potential contaminants associated with those uses;
 - a conceptual model of the site indicating sources, pathways and receptors; and
 - potentially unacceptable risks arising from contamination at the site;
 - II. A site investigation scheme, to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site;
 - III. The results of the site investigation and the detailed risk assessment referred to in (II) and, based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken; and
 - IV. A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in the remediation strategy in (III) are complete and identifying any requirements for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action. The remediation strategy and its relevant components shall be carried out in accordance with the approved details.

Planning Condition No. 7 (Verification Reporting)

- 1.4.3 Prior to commencement of development a verification report demonstrating completion of works set out in the approved remediation strategy and the effectiveness of the remediation shall be submitted to and approved in writing by the Local Planning Authority. The report shall include results of sampling and monitoring carried out in accordance with the approved verification plan to demonstrate that the site remediation criteria have been met. It shall also include a long-term monitoring and maintenance plan for longer-term monitoring of pollutant linkages, maintenance

and arrangements for contingency action, as identified in the verification plan. The long-term monitoring and maintenance plan shall be carried out in accordance with the approved details.

Planning Condition No. 8 (Monitoring plan for land contamination)

- 1.4.4 Prior to the occupation or operation of the development, a long-term monitoring plan for land contamination shall be submitted and approved in writing by the Local Planning Authority. The long-term monitoring plan should include:
- Details of the methods and triggers for action to be undertaken;
 - Timescales for the long-term monitoring and curtailment mechanisms e.g. a scheme of monitoring for 3 years unless the monitoring reports indicate that subsequent monitoring is not required;
 - Timescales for submission of monitoring reports to the LPA e.g., annually;
 - Details of any necessary contingency and remedial actions and timescales for actions;
 - Details confirming that the contingency and remedial actions have been carried out. The monitoring plan shall be carried out in accordance with the approved details, within the agreed timescales.

Planning Condition No. 9 (Contamination remediation strategy)

- 1.4.5 If, during development, contamination not previously identified is found to be present at the site then no further development (unless otherwise agreed in writing with the Local Planning Authority) shall be carried out until a remediation strategy detailing how this unsuspected contamination shall be dealt with has been submitted to and approved in writing by the Local Planning Authority. The remediation strategy shall be carried out as approved.

Planning Condition No. 10 (Details of piling)

- 1.4.6 No development or phase of development, shall commence until details of piling or any other foundation designs using penetrative methods sufficient to demonstrate that there is no unacceptable risk to groundwater have been submitted to and approved in writing by the Local Planning Authority. The piling/foundation designs shall be implemented in accordance with the approved details.

Planning Condition No. 11 (Infiltration permission)

- 1.4.7 No infiltration of surface water drainage into the ground at the proposed Wrexham FC Kop stand location is permitted other than with the express written consent of the Local Planning Authority, which may be given for those parts of the site where it has been demonstrated that there is no resultant unacceptable risk to controlled waters. The development shall be carried out in accordance with the approved details.

1.5 Sustainability

- 1.5.1 The United Nations (UN) 2030 Agenda for Sustainable Development sets 17 Sustainable Development Goals (SDGs) which are designed to promote the achievement of a better and more sustainable future for all.
- 1.5.1 Contamination and pollution are recognised by the United Nations as risks to human health and wellbeing as well as sustainability of the places where we live. A target to substantially reduce those risks is enshrined in the UN Sustainable Development Goal (SDG) No 3: Good Health and Wellbeing, as well as SDG No. 11: Sustainable Cities and Communities, which also emphasises

sustainable management of waste. Pollution is likewise recognised as a potential threat to water quality, both for human consumption and for its ability to support water-related ecosystems (UN SDG No. 6: Clean Water and Sanitation).

- 1.5.2 Contamination and pollution within soils, water and air at the site have been identified through the conceptual site model development process and strategic sampling and analysis. Characterisation and, if recommended as a result of the assessment contained within this report, remediation of contamination at the site thus directly support achievement of UN strategy. Implemented through technically robust investigation and risk assessment this focusses the proposals for remedial works where there is a scientifically justifiable need, thus minimising the carbon footprint of works carried out (supporting SDG No 13: Climate Action) as well as production of waste (SDG No. 11).
- 1.5.3 In order to recognise where the GQRA works completed are of relevance to the progression of the UN's SDG objectives, reference is made in this report to relevant SDGs.

1.6 Constraints and Limitations

- 1.6.1 This report has been prepared by Ramboll exclusively for the intended use by the client in accordance with the agreement, 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.
- 1.6.2 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.
- 1.6.3 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.
- 1.6.4 Unless otherwise stated in this report, the scope of services, assessment and conclusions made assume that the site will continue to be used for its current purpose and end-use without significant changes either on-site or off-site.
- 1.6.5 The ground 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.
- 1.6.6 Overall, Geotechnics Ltd was able to investigate the identified the identified potential contaminant sources and it is considered that the exploratory holes provide an appropriate an appropriate coverage across the accessible areas of the site.

2. SUMMARY OF TIER 1 PRELIMINARY RISK ASSESSMENT

- 2.1.1 Details of the Preliminary Risk Assessment (PRA) for the site are provided in full in the Kop Development Geotechnical and Contaminated Land Desk Study Report (1620012485-RAM-XX-XX-RP-CE-00001). The section below provides a summary of the key findings and details the relevant potential contaminant linkages (PCLs) which were identified as needing further investigation and quantification. Significant PCLs are those which were assessed in the PRA to be at low-moderate risk or of higher risk.
- 2.1.2 This section summarises information gathered from the Ramboll Geotechnical and Contaminated Land Desk Study Report, which was produced in general accordance with Tier 1: Preliminary Risk Assessment (PRA) of Stage 1 of LCRM.

2.2 Description of Site and Setting

- 2.2.1 The site location is at National Grid reference SJ 32885 50952 as shown in Figure 1; it comprises an irregular plot of land of an area of approximately 3.3 hectares (ha).
- 2.2.2 The site can be defined as the area of land currently occupied by the existing, derelict Kop stand and a parcel of land lying immediately to the east. In addition, an area of land between the site and Crispin Lane is intended to be used as a compound during construction works and part of this area is proposed to be used as access to the new stand.
- 2.2.3 Currently the ground surface in this area comprises demolition rubble associated with removal of the former buildings which occupied the area.
- 2.2.4 The following sites have been designated as being environmentally sensitive, and were identified in the PRA as potential receptors of contamination arising at the site and within the surrounding area:
- The nearest statutory designated site is the Gatewen Marsh Site of Special Scientific Interest which is located approximately 715m west of the site;
 - A number of ecologically valuable plan species are present to the northern end of the area between the existing stand and Crispin Lane.
- 2.2.5 A summary of the expected geological conditions at the site is provided in Table 2-1, this information was sourced from the Kop Development Geotechnical and Contaminated Land Desk Study Report (1620012485-RAM-XX-XX-RP-CE-00001).

Table 2-1 Summary of Anticipated Geology and Hydrogeology

Stratum	Estimated Average Thickness (m)	Description	Aquifer Designation
Made Ground	Unknown	Currently unknown but anticipated to contain concrete / brick and by of a reworked nature	N/A
Glaciofluvial Sheet Deposits	Unknown	Sand and Gravel	Secondary A
Etruria Formation	Up to 300m	Mudstone	Secondary A
Carboniferous Lower Pennine Coal Measures Formation	Unknown	Mudstone, siltstone and sandstone	Secondary A

2.2.6 The Coal Authority identified coal working beneath the site at 365 metres below ground level (m bgl) and to the northwest of the site, coal mining took place at depths ranging from 322m bgl and 352m bgl.

2.2.7 The site is located in an area where basic radon protection measures will be required.

2.3 Current and Former Land Uses with Potential for Contamination

2.3.1 No potentially significantly contaminating land uses have been identified within the development site area. However, a large mound is present which supports the existing stand and historical maps from the early 1900s to mid-1900s show this increased in size prior to a stand first being shown in the 1970s.

2.3.2 Land uses identified within the construction compound area includes a former drill shed and a garage which extended further to the south.

2.3.3 A number of potentially contaminating land uses have been identified within the surrounding area (<250m) which include:

- Various railway uses (railway lines, sidings, station, goods shed / depot, oil tanks);
- Various works including a saw mill with timber yard, Cambrian Iron Works / Cambrian Works (engineering), joinery, depot, warehouses;
- Garages and petrol stations; and
- Scrap yard

2.3.4 Made ground associated with the existing football ground stand area was expected to be present.

2.4 Preliminary Conceptual Site Model (CSM)

2.4.1 The main environmental legislation relating to contaminated land in the UK is Part 2A of the Environmental Protection Act 1990 (England and Wales). The philosophy behind Part 2A is the source-pathway-receptor potential contaminant 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). Further details are provided in Appendix 1.

2.4.2 A preliminary conceptual site model that identifies those potential contaminant linkages forms the output of the PRA and 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.

- A key aspect of LCRM is that the GQRA should assess the potential contaminant linkages identified in the preliminary conceptual site model. Those PCLs which were identified in the PRA's CSM are presented below: No significant existing or historical contamination sources identified on-site however Made Ground would be present across the development footprint therefore the potential contamination linkage to future site users and construction workers exists through dermal contact and/or ingestion for any impacted material if present. Risk assessed as low for future site users and moderate for construction workers.
- Potential contamination linkage to future site users and construction workers from gases and vapours from inhalation from potential gas generating material within the Made Ground across the site. Risk assessed as low to moderate to future site users and moderate to construction workers.
- Potential contamination linkage exists for leaching of contaminants from the Made Ground to the underlying Secondary A Aquifers in the Glaciofluvial Sheet Deposits and Etruria Formation. Risk assessed as low to underlying Secondary A Aquifer.

- No surface water courses onsite or close to site therefore potential for impacted runoff to run into nearby drains. Risk assessed as low.
- Potential contamination linkage for contamination within Made Ground to impact onsite buildings. Risk assessed as low.
- A number of potential off site sources (current and historical) have been identified which have the potential to impact underlying groundwater and for gases to migrate onto site. Risk assessed as moderate / low for both risk to groundwater from off-site sources and ground gas migration onto site from off-site sources.

2.4.3 The ground investigation was designed to assess the PCLs above. The following sections describe the ground investigation strategy, the results of laboratory chemical analysis and monitoring and a qualitative source-pathway-receptor risk assessment. A revised conceptual model is then presented.

3. GROUND INVESTIGATION

3.1 Design

- 3.1.1 The ground investigation was designed to investigate the ground, ground gas and groundwater conditions at the site and to test the preliminary conceptual site model, focussing on the assessment of PCLs identified in Section 2.4. The investigation was undertaken by Geotechnics Ltd on behalf of Ramboll and is split into two phases:
- Pre-demolition investigation for the floodlight foundations.
 - Post-demolition investigation to inform construction of the new stand and external works.
- 3.1.2 The ground investigation was undertaken in order to obtain detailed information on the ground conditions at the site. The exploratory holes locations targeted distinct areas of the proposed development such as locating deeper boreholes to inform the piling requirements for the proposed Kop stand, and targeting potential contamination source areas such as made ground.
- 3.1.3 An additional six trial pits were excavated into the mound which the old Kop Stand was constructed on by the demolition contractor P.P. O'Conner Ltd for waste classification purposes. A total of 15 samples were taken from the six trial pits. These samples have been included within the assessment but it should be noted this material has since been excavated by P.P. O'Connor Ltd and removed from the site.

3.2 Ground Investigation Activities

- 3.2.1 Site works for the phased ground investigation were undertaken in two phases from 28 September 2022 to 18 October 2022 and 15 February 2023 to 28 February 2023. The ground investigation was undertaken by Geotechnics Ltd for the ground investigation works.
- 3.2.2 The ground investigation was undertaken in general accordance with:
- BS 5930 Code of Practice for Ground Investigation³; and
 - BS 10175 Investigation of Potentially Contaminated Sites – Code of Practice⁴.
- 3.2.3 The level of investigation designed for is considered by Ramboll to be 'Detailed' with respect to BS 10175.
- 3.2.4 A summary of the scope of the investigation undertaken at the site is presented in Table 3-1. Exploratory locations are shown on Figure 2. Borehole logs (including monitoring well details) are provided in Appendix 2.

Table 3-1 Summary of Intrusive Works (Phase I & Phase II investigations)

Item	No.	Comments
Utilities Clearance Survey	Item	Prior to intrusive works a specialist service location contractor, appointed by Geotechnics Ltd was contracted to locate below ground services and mark out drilling locations.
Boreholes	7 No.	Drilling method: Cable Percussion or Rotary open hole (at BH103) <i>Phase I Floodlights - Pre-demolition Investigation</i> Three percussion boreholes with (BH100- BH102) to depths between 20.37m to 30.42mgl. One open hole (BH103) to 20.0m bgl <i>Phase II New Kop Stand - Post-demolition investigation</i> Three percussion boreholes with rotary follow on (BH104-BH106) to depths between 15.43m to 20m bgl.

³ BS 5930 Code of practice for ground investigations BS 5930:2015 +A1:2020

⁴ BS 10175 Investigation of Potentially Contaminated Sites – Code of Practice BS 10175:2011 + A2:2017

Item	No.	Comments
Trial Pitting	5 No.	Method: Mechanical excavator. Depth range (m): 3 m bgl.
Inspection Pits	2 No.	Method: Hand excavation. Depth Range: 1.35m bgl.
Soil Sampling and Screening	41 No.	During the ground investigation, soil samples were recovered from each exploratory hole location for geotechnical and contamination testing. All environmental samples were subject to screening on-site using a hand-held photo-ionisation detector (PID) for the presence of volatile organic compounds. This was only undertaken during the Phase I Floodlights ground investigation including BH100-BH103. A total of 41 soil samples were scheduled for analysis. Selected soil samples were analysed for a predetermined suite of contaminants (see Section 4.3.5), selected to be reflective of the site's historical and contemporary uses. 35 of the 41 soil samples tested were subjected to leachate testing.
Groundwater Sampling and Monitoring	7 No.	An oil/water interface probe was used to check for free-phase hydrocarbons and resting groundwater levels were monitored. Variable head testing was undertaken in two boreholes at a depth of 3m.
Gas Monitoring	6 No.	Ground gas monitoring was undertaken using a portable gas analyser
Waste Characterisation for Disposal	Item	All soil and groundwater arisings along with general waste generated during the works were disposed off-site by the ground investigation contractor in accordance with relevant legislation.

3.3 Sampling and Monitoring

- 3.3.1 Details of the general sampling and monitoring methods utilised during the investigation are provided in within the Geotechnics Factual Report in Appendix 2. Project-specific details are summarised below.
- 3.3.2 Soil samples were recovered at each of the exploratory locations where there were changes in strata or any visual or olfactory evidence of contamination. The spacing was amended to take this into account where applicable or additional samples were recovered. A total of forty one (41) soil samples were scheduled for analysis. Thirty five (35) of these soil samples were also scheduled for leachate preparation and analysis.
- 3.3.3 It should be noted that barium was only tested for in the Phase I Floodlights ground investigation including BH100-BH103 and shallow foundation inspection pits IP100 and IP101.
- 3.3.4 Two Waste Acceptance Criteria (WAC) samples were obtained from each borehole and trial pit-one from the made ground and one from the natural soils.
- 3.3.5 All 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. All soil samples were labelled with the borehole location, site reference, date and sample depth.
- 3.3.6 Groundwater samples were recovered from all installing monitoring locations by Geotechnics Ltd.
- 3.3.7 Monitoring of waters and ground gas was undertaken at selected locations, details of which are summarised in
- 3.3.8 Table 3-2.

Table 3-2 Summary of Monitoring Locations

Monitoring Wells				
Monitoring Position	Response Zone (mbgl)	Response Zone (mAOD)	Response Zone Strata	Monitoring Purpose
BH100	23.50 to 25.50	62.88 to 60.88	Glaciofluvial Sheet Deposits	Groundwater
BH101	7.00 to 10.00	81.22 to 78.22	Glaciofluvial Sheet Deposits	Groundwater
BH102	12.90 to 15.90	75.69 to 72.69	Glaciofluvial Sheet Deposits	Groundwater
BH103	13.50 to 15.60	74.44 to 72.34	Glaciofluvial Sheet Deposits	Groundwater
BH104	1.00 to 2.80	87.54 to 85.74	Made Ground	Ground Gas
	12.00 to 15.00	76.54 to 73.54	Glaciofluvial Sheet Deposits	Groundwater
BH105	0.50 to 2.00	88.04 to 86.54	Made Ground	Ground Gas
	12.00 to 15.00	76.54 to 73.54	Glaciofluvial Sheet Deposits	Groundwater
BH106	1.00 to 2.70	87.58 to 85.88	Made Ground	Ground Gas
	15.00 to 18.00	73.58 to 70.58	Glaciofluvial Sheet Deposits	Groundwater

3.3.9 Table 3-3 summarises the analytical schedule for the samples tested together with the rationale for analysis. The laboratory selected to perform the analysis for the phased ground investigation was Derwentside Environmental Testing Services (DETS) in Durham who are a UKAS⁵ accredited laboratory.

Table 3-3 Summary of Analytical Strategy

Analytical Suite	Rationale	Number of Samples Tested		
		Soil	Leachate	Ground water
Total Petroleum Hydrocarbons Carbon Working Group (TPH CWG)	Typically associated with fuels and oils. May be present in elevated concentrations in historic fill material depending on point of origin.	38	35	7
Metals (including antimony, arsenic, cadmium, chromium, boron, barium, lead, mercury, copper, nickel, zinc, and selenium) <i>It should be noted that barium was only analysed in the Phase I Floodlights GI.</i>	Typically associated with brownfield sites	41 <i>Exception of barium with 21 samples tested.</i>	35 <i>Exception of boron with 15 samples tested.</i>	7

⁵ United Kingdom Accreditation Service

Analytical Suite	Rationale	Number of Samples Tested		
		Soil	Leachate	Ground water
Asbestos screen	Commonly associated with Made Ground and locations of historical infilling.	29	N/A	N/A
Polycyclic Aromatic Hydrocarbons (PAH)	Typically associated with fuels and oils.	38	35	7
Volatile Organic Compounds (VOCs)	Typically associated with organic solvents and fuels and oils.	20	-	3
Semi-Volatile Organic Compounds (SVOCs)	Typically associated with organic solvents and fuels and oils	37	-	0
Inorganics- total organic carbon (TOC), sulphate. Ammoniacal nitrogen	Used to characterise the soils and groundwater and derive an assessment criterion for some metals	41	35	7
Water soluble sulphate	Typically associated with Made Ground	41	-	0

3.3.10 The 15 samples of the mound beneath the old Kop Stand taken by P.P O'Conner Limited as part of the additional ground investigation were screened for metals, inorganic, PAHs, TPH, VOC including tentatively identified compounds (TICs) and SVOC including TICs and asbestos screening. No trial pit logs, soil descriptions or photos were provided for the mound material.

3.4 Field Observations

Ground Conditions

3.4.1 An overview of the ground conditions encountered during the phased ground investigation has been provided below. A full lithological description is recorded in the exploratory hole logs which are provided in Appendix 2.

Table 3.4 Summary of Ground Conditions

Stratum	Description	Depth to Base (mbgl)	Approximate Thickness Range (where encountered) (m)
Made Ground	Made ground was present in all exploratory hole locations with the greatest depth observed in BH104. This generally comprised a gravelly very clayey fine to coarse sand with occasional brick fragments.	0.0-2.80	0.1 – 2.80

Stratum	Description	Depth to Base (mbgl)	Approximate Thickness Range (where encountered) (m)
Superficial Deposits	Glaciofluvial sheet deposits were present in all exploratory locations underlying the Made Ground encountered at depths ranging between 0.10m bgl (TP100) to 2.80m bgl (BH104). The glaciofluvial sheet deposits were unproven in all locations to a maximum depth of 30.42m bgl (BH100). Glaciofluvial sheet deposits consisted of interbedded cohesive and granular material. Granular material generally consisted of either sandy clayey GRAVEL or silty slightly gravelly fine to coarse SAND. Cohesive material generally consisted of slightly gravelly slightly sandy CLAY.	30.42 (unproven)	0.25 - 29.67

3.4.2 Table 3.5 provides information of the exploratory hole locations across the phased ground investigation.

Table 3.5 Summary of Exploratory Hole Locations

Exploratory Location	Depth achieved (m)	Coordinates		Ground Level (mAOD)	Remarks
		Easting (m)	Northing (m)		
BH100	30.42	332776.8	351079.5	86.38	Shallow well install to 25.50m
BH101	20.37	332729.7	350972.2	88.22	Installed to 10m
BH102	30.0	332843.9	350918.6	88.59	Installed to 15.90m
BH103	20.0	332878.6	350989.5	87.94	Installed to 15.60m
BH104	15.45	332874.1	350946.0	88.54	Dual install to 2.80m and 15.0m
BH105	15.43	332880.0	350909.0	88.54	Dual install to 2.0m and 15.0m
BH106	20.0	332914.1	350958.2	88.58	Dual install to 2.70m and 18.0m
IP100	1.35	332782.8	351075.5	86.35	n/a
IP101	1.35	332778.8	351070.5	86.36	n/a
TP100	3.0	332937.0	350962.0	87.42	n/a
TP101	3.0	332925.0	350927.0	87.80	n/a

Exploratory Location	Depth achieved (m)	Coordinates		Ground Level (mAOD)	Remarks
		Easting (m)	Northing (m)		
TP102	3.0	332920.0	350916.0	87.90	n/a
TP103	3.0	332913.0	350904.0	87.85	n/a
TP104	3.0	332890.0	350899.0	87.53	n/a
Note: BH-cable percussion/rotary borehole, TP- trial pit					

3.4.3 Table 3.6 provides information of where notable visually or olfactory impacted soils were recorded, and any associated readings made using a photoionisation detector (PID) to correlate with the location of possible volatile substances. It should be noted that a PID readings were only undertaken for the Phase I Floodlights ground investigation including BH100-BH103.

Table 3.6 Summary of Observations in Soils

Exploratory Location	Observations	PID Reading (parts per million (ppm))
BH100	Presence of coal and brick fragments in the made ground between 0.50m and 0.75mbgl.	<0.1
BH101	Presence of coal and brick fragments in the made ground between 0.30m and 0.70mbgl.	<0.1
BH102	Presence of clinker in the made ground between 0.30m and 0.70mbgl.	<0.1
TP104	Strong hydrocarbon odour between 1.0 to 1.8m bgl	-

Groundwater

3.4.4 The depth to resting groundwater level and details of non-aqueous phase liquid (NAPL) were recorded during the groundwater monitoring rounds. A summary of the groundwater levels and evidence for contamination observed throughout the monitoring period is provided in Table 3-7.

Table 3-7 Summary of Groundwater Observations

Monitoring Well	Groundwater Encountered?	NAPL Encountered	Range in Depth to Groundwater (mbgl)	Range in Groundwater Elevation (mAOD)	Inferred Aquifer Containing Groundwater ¹	Evidence for Contamination	Range of PID readings (ppm)	Number of Monitoring Rounds
BH100	Yes	None	5.25 - 5.65	80.73 - 81.13	Glaciofluvial sheet deposits	No	0	6

Monitoring Well	Groundwater Encountered?	NAPL Encountered	Range in Depth to Groundwater (mbgl)	Range in Groundwater Elevation (mAOD)	Inferred Aquifer Containing Groundwater ¹	Evidence for Contamination	Range of PID readings (ppm)	Number of Monitoring Rounds
BH101	Yes	None	8.27 - 8.45	79.77 - 79.95	Glaciofluvial sheet deposits	No	0	6
BH102	Yes	None	9.54 - 9.78	78.81 - 79.05	Glaciofluvial sheet deposits	No	0	6
BH103	Yes	None	8.98 - 11.50	76.44 - 78.96	Glaciofluvial sheet deposits	No	0	6
BH104 (Deep)	Yes	None	9.62 - 9.70	78.88 - 78.80	Glaciofluvial sheet deposits	No	0	6
BH104 (Shallow)	Yes	None	Dry - 2.77	N/A	Made ground	No	0	6
BH105 (Deep)	Yes	None	9.70 - 9.87	78.79 - 78.62	Glaciofluvial sheet deposits	No	0	6
BH105 (Shallow)	No	None	N/A	N/A	Made ground	N/A	0	6
BH106 (Deep)	Yes	None	9.91 - 10.00	78.65 - 78.56	Glaciofluvial sheet deposits	No	0	6
BH106 (Shallow)	No	None	N/A	N/A	Made ground	N/A	0	6

Notes: ¹ The inferred horizon has been identified by comparing the resting groundwater levels against the exploratory hole logs and monitoring well design

LNAPL – Light non-aqueous phase liquid, DNAPL – dense non-aqueous phase liquid

3.4.5 The range in recorded groundwater elevations was 76.44 to 79.95 m AOD; however, groundwater levels fluctuate as a result of changing weather. Based on groundwater level monitoring data, the inferred groundwater flow direction is in an approximate northeast direction.

4. HUMAN HEALTH ASSESSMENT

4.1 Assessment Approach

- 4.1.1 This assessment has been undertaken in general accordance with the current UK framework and comprises a GQRA as defined in LCRM⁶. Ramboll's assessment methodology is based on the Contaminated Land Exposure Assessment (CLEA) approach, further details of which are presented in Appendix 1.
- 4.1.2 LCRM requires that the use of GAC is appropriate for a range of management and site-specific technical factors. In choosing the GAC for human health assessment, Ramboll has considered stakeholder requirements, the complexity of the conceptual site model, combined and cumulative factors, potential changes in site circumstances, uncertainties and limitations.
- 4.1.3 Ramboll has derived 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).
- 4.1.4 GAC have been adopted for commercial/industrial end land use. This is based upon the proposed end use of the site as a football stadium, however this is considered conservative as commercial/industrial end use is based on workers within or on the new stand. However, workers within the stadium and users of the stadium are likely to be present for a limited time, therefore reducing exposure time to potential pathways and sources of contamination. A conservative soil organic matter (SOM) of 1% has been adopted for the assessment.
- 4.1.5 Chemical analyses are discussed below and are provided in full in Appendix 3. Laboratory certificates are provided in Appendix 2 (Geotechnics Factual Report Appendices 9 and 10).

4.2 Analytical Results - Soils

- 4.2.1 A review of the soil testing obtained during the phased ground investigation are detailed in Table 4.1. Contaminations that were below the method detection limit are excluded from the table. The tests results from the P.P. O'Conner Ltd testing of the mound beneath the old Kop Stand are included within the screening of analytical results.
- 4.2.2 The following determinands were not detected above the laboratory method report limits and therefore not included in Table 4.1:
- Total Petroleum Hydrocarbons (TPH) fraction: aromatic C5-C7
 - Semi-volatile organic compounds with the exception of 4-nitrophenol, dibenzofuran, di-n-butylphthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate and carbazole
 - Volatile organic compounds

⁶ Land contamination risk management (LCRM) - GOV.UK (www.gov.uk)

Table 4-1 Summary of Chemical Test Results on Soil Samples collected from the Site

Contaminant	Total No. of Samples	GAC (mg/kg)	No. of Exceedances of GAC	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg), location and depth (m bgl)
Metals					
Antimony	41	7,400	0	<MRL	6.1 (TP100 at 0.05m)
Arsenic	41	640	0	2.6	21 (IP101 at 1.0m)
Barium	21	22,000	0	24	320 (IP100 at 0.80m)
Boron (water soluble)	41	240,000	0	<MRL	1.9 (TP02 at 0.70m)
Cadmium	41	410	0	<MRL	5.6 (TP02 at 0.50m)
Chromium III	41	8,600	0	<MRL	440 (TP100 at 0.05m)
Chromium VI	41	49	0	<MRL	1.2 (IP101 at 0.20m)
Copper	41	68,000	0	9.8	93 (BH104 at 0.20m)
Lead	41	2,300	0	<MRL	1,300 (BH104 at 0.20m)
Mercury	41	1,100	0	<MRL	1.1 (BH104 at 0.20m)
Nickel	41	980	0	<MRL	40 (IP100 at 0.80m)
Selenium	41	12,000	0	<MRL	1.4 (BH101 at 1.00m)
Zinc	41	730,000	0	16	1,500 (TP103 at 0.40m)
Vanadium	21	9,000	0	5	64 (IP101 at 0.20m)

Contaminant	Total No. of Samples	GAC (mg/kg)	No. of Exceedances of GAC	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg), location and depth (m bgl)
Total Petroleum Hydrocarbons (TPH)					
Aliphatic C5-C6	41	2,400	0	<MRL	0.14 (BH101 at 6.0m)
Aliphatic C6-C8	41	5,300	0	<MRL	0.02 (TP104 at 1.50m)
Aliphatic C8-C10	41	1,300	0	<MRL	0.05 (TP104 at 1.50m)
Aliphatic C10-C12	41	6,100	0	<MRL	6.1 (TP104 at 1.50m)
Aliphatic C12-C16	41	43,000	0	<MRL	8.6 (TP104 at 1.50m)
Aliphatic C16-C21	41	1,000,000	0	<MRL	22 (TP104 at 1.50m)
Aliphatic C21-C35	41	1,000,000	0	<MRL	1,300 (TP104 at 1.50m)
Aromatic C7-C8	41	NC	N/A	<MRL	0.02 (TP104 at 1.50m)
Aromatic C8-C10	41	2,200	0	<MRL	0.16 (TP104 at 1.50m)
Aromatic C10-C12	41	11,000	0	<MRL	2.3 (IP101 at 0.20m)
Aromatic C12-C16	41	35,000	0	<MRL	10 (TP104 at 1.50m)
Aromatic C16-C21	41	29,000	0	<MRL	50 (TP104 at 1.50m)
Aromatic C21-C35	41	29,000	0	<MRL	820 (TP104 at 1.50m)
Polyaromatic Hydrocarbons (PAHs)					
Naphthalene	38	110	0	<MRL	0.5 (TP104, 1.50m)

Contaminant	Total No. of Samples	GAC (mg/kg)	No. of Exceedances of GAC	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg), location and depth (m bgl)
Acenaphthylene	38	76,000	0	<MRL	0.7 (TP104, 1.50m)
Acenaphthene	38	75,000	0	<MRL	0.2 (BH105, 0.20m)
Fluorene	38	60,000	0	<MRL	1.0 (TP104, 1.50m)
Phenanthrene	38	22,000	0	<MRL	2.5 (BH105, 0.20m)
Anthracene	38	520,000	0	<MRL	1.8 (TP104, 1.50m)
Fluoranthene	38	23,000	0	<MRL	4.5 (BH105, 0.20m)
Pyrene	38	54,000	0	<MRL	4.3 (BH105, 0.20m)
Benzo(a)pyrene	38	76	0	<MRL	2.8 (BH105, 0.20m)
Semi-Volatile Organic Compounds (SVOCs)					
4-Nitrophenol	38	3,800	0	<MRL	0.8 (BH102, 0.10m)
Dibenzofuran	38	6,700	0	<MRL	0.4 (BH102, 0.20m)
Di-n-butylphthalate	38	15,000	0	<MRL	0.1 (TP104, 0.25m)
Butylbenzylphthalate	38	940,000	0	<MRL	0.4 (TP104, 0.25m)
Bis(2-ethylhexyl)phthalate)	38	85,000	0	<MRL	5.2 (TP104, 1.50m)
Carbazole	38	900	0	<MRL	0.4 (BH106, 0.20m)

Contaminant	Total No. of Samples	GAC (mg/kg)	No. of Exceedances of GAC	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg), location and depth (m bgl)
Additional Inorganics					
Total cyanide	41	49	0	<MRL	11 (BH104, 2.0m)
Water Soluble Sulphate as SO ₄ 16hr extraction(2:1), as mg/l	41	NC	N/A	11	1500 (TP101, 0.25m)
pH	41	NC	N/A	6.7 (TP02, 0.70m)	10.9 (TP103, 0.20m)
Total Organic Carbon	41	NC	N/A	<MRL	12 (BH102, 0.50m)
Asbestos Screen	29	NC	N/A	NAD	<0.001% chrysotile fibre bundles at IP101, 0.20m
Notes: MRL- Method Reporting Limit NC- No Criteria N/A- Not Applicable					

4.3 Hydrocarbon Theoretical Saturation Assessment

- 4.3.1 A number of soil test results recorded concentrations of petroleum hydrocarbons in excess of theoretical saturation limits which are indicative of the potential presence of free phase hydrocarbons. The locations concerned comprise:
- Aromatic fractions C21-C35 exceeded the saturation limit of 4.8mg/kg at 12 sample locations (TP100 0.05m, TP101 at 0.25m, TP102 at 0.50m, 0.70m, TP103 at 0.20m, TP104 at 0.25m and 1.50m, BH104 at 0.20m, IP100 at 0.30m and 0.80m and IP101 at 0.20m and 1.0m); and
 - Aromatic fractions C35-C44 exceeded the saturation limit of 4.8mg/kg at 13 sample locations detailed above with the addition of BH104 at 2.0m.
- 4.3.2 These theoretical exceedances were not supported by visual / olfactory observations in the field and it is considered unlikely that the theoretical exceedance represents a potential for free phase product to be present.

4.4 Analytical Results

Asbestos

- 4.4.1 Asbestos was detected in 1 of 29 samples screened by the laboratory from the phased ground investigation. Quantification analysis recorded the asbestos content of the sample to be <0.001% by weight, which is below the hazardous threshold of 0.1% (by weight). The chrysotile fibre bundles were identified within the Made Ground in IP101 at 0.20m bgl which is located to the north-west corner of the site. If Made Ground were to be removed from the site during the proposed development, further assessment with regard to asbestos concentrations may be necessary.

Soil

- 4.4.2 Elevated levels of barium (IP100 at 0.80m bgl, 320 mg/kg), chromium (TP100 at 0.05m bgl, 440 mg/kg), copper (BH102 at 0.10mbgl at 110mg/kg and 0.50m bgl, 190mg/kg and IP101 at 0.20m bgl, 130 mg/kg) and lead (BH104 at 0.20m bgl, 1300 mg/kg) were identified. However, the concentrations of all metals tested within the New Kop Stand and Flood lights ground investigation were below their respective GAC for commercial/industrial land use.
- 4.4.3 Results for PAHs (as a sum of 16 compounds) were identified above the method detection limit in 18 samples with the maximum concentration of 29mg/kg at BH105, 5.0m bgl however none of these exceeded the Ramboll human health screening criteria for commercial end use.
- 4.4.4 Elevated concentrations of total petroleum hydrocarbons (TPH) were identified within the sandy gravel at TP104 at 1.50m bgl at the following concentrations: aliphatic C21-C35 at 1,300mg/kg, aliphatic C10-C44 at 1,400 mg/kg, aromatic C21-C35 at 820 mg/kg and aromatic C10-C44 at 1,000 mg/kg. Elevated TPH fractions were not identified in any other locations with none of the concentrations found to exceed the Ramboll commercial/industrial GAC.
- 4.4.5 The 15 samples taken from the mound to characterise the material for off-site disposal by P.P. O'Connor were screened against human health criteria with only one exceedance recorded of lead within TP3 at 0.5m bgl (5,967mg/kg) exceeding the screening criteria of 2,300 mg/kg. It should be noted this material has been removed from site.

4.5 Analytical Results - Groundwater (Human Health)

- 4.5.1 The groundwater analytical results obtained during this investigation have been screened against the GAC for commercial / industrial end use. The exceedances recorded as part of the screening are summarised in Table 4-2.
- 4.5.2 The determinands which were not detected above laboratory reporting limits include:

- Aliphatic petroleum hydrocarbons fractions C5-C6, C6-C8, C8-C10, C10-12, C12- C16, C21-C35 and C35-C44.
- Aromatic petroleum hydrocarbon (all fractions)
- Benzene, Toluene, Ethylbenzene, p & m-xylene, o-xylene (BTEX)
- Nine PAHs (acenaphthylene, anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, Dibenzo(a,h)anthracene, Benzo(a)anthracene and benzo[g,h,i]perylene)
- Phenols
- Methyl Tertiary Butyl Ether (MTBE)
- Volatile Organic Compounds not mentioned in Table 4.2
- Semi-volatile Organic Compounds.

4.5.3 With the exception of mercury, there is no volatilisation pathway for inorganic including metals determinands, and therefore is discounted from the assessment in Table 4.2.

4.6 Human Health Discussion

4.6.1 The existing site and proposed Kop stand development is considered to be a low sensitivity land use in terms of risk to site users. Asbestos was detected in one of the 29 samples screened by the laboratory from the phased ground investigation at the site. Chrysotile fibre bundles (<0.001%) were identified in the made ground in IP101 which is located to the north-west corner of the site associated with the Phase I floodlights ground investigation. No visual evidence of asbestos containing materials were observed and no asbestos was recorded in the remaining samples.

Groundwater (Human Health)

4.6.2 No groundwater concentrations were detected exceeding the human health pathway for groundwater volatilisation for a residential and commercial end use.

Construction Workers

4.6.3 This report and the GAC consider long term and chronic risk to humans based on defined exposure scenarios set out in the CLEA model and in CAR-SOIL for asbestos impacts. 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.

4.6.4 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 Regulations⁷, Construction (Design and Management) Regulations⁸ (for some sites) and the Control of Substances Hazardous to Health Regulations⁹.

⁷ UK Statutory Instruments (1999) The Management of Health and Safety at Work Regulation No. 3242

⁸ UK Statutory Instruments (2015) Construction (Design and Management) Regulations No. 51

⁹ UK Statutory Instruments (2002) Control of Substances Hazardous to Health Regulations No. 2677

Table 4-2 Summary of Groundwater Analytical Results (Human Health)

Contaminant	No. of Samples	Conc. Range (µg/l)	Location of Max. (µg/l)	Ramboll Water GAC for Human Health (Commercial) (µg/l)	No of Exceedances	Location of Exceedances
Metals						
Mercury	7	<MRL – 0.03	BH101	95	0	N/A
Polycyclic Aromatic Hydrocarbons						
Naphthalene	7	<MRL – 0.11	BH100	23,000	0	N/A
Acenaphthene	7	<MRL – 0.01	BH100, BH104, BH106	15,000,000	0	N/A
Fluorene	7	<MRL – 0.01	BH106	18,000,000	0	N/A
Phenanthrene	7	<MRL – 0.02	BH104	NC	0	N/A
Fluoranthene	7	<MRL – 0.03	BH106	NC	0	N/A
Pyrene	7	<MRL – 0.04	BH106	NC	0	N/A
Benzo(a)anthracene	7	<MRL – 0.01	BH106	NC	0	N/A
Total Petroleum Hydrocarbons						
Aliphatic C10 – C44	7	<MRL – 16	BH100	NC	0	N/A
Aliphatic C16 – C21	7	<MRL – 15	BH100	NC	0	N/A
Volatile Organic Compounds						
Chloroform	3	3 – 9	BH106	85,000	0	N/A
Bromodichloromethane	3	<MRL – 5	BH106	1,600	0	N/A
Dibromochloromethane	3	<MRL – 2	BH106	NC	0	N/A
Notes: MRL- Method Reporting Limit NC- No Criteria N/A- Not Applicable						

5. WATER ENVIRONMENT ASSESSMENT

5.1 Assessment Approach

- 5.1.1 LCRM requires that the use of GAC is appropriate for a range of management and site-specific technical factors. In defining GAC for the water environment, Ramboll has considered stakeholder requirements, the complexity of the conceptual site model, combined and cumulative factors, potential changes in site circumstances, uncertainties and limitations.
- 5.1.2 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).
- 5.1.3 The potential receptors in the water environment which have been identified comprise:
- Groundwater in the underlying Secondary A Aquifers in the Superficial and Bedrock Aquifers; and
 - Surface water runoff into adjacent drainage network.
- 5.1.4 Assessment of the risk to these receptors is required using the appropriate GAC which are protective of that specific receptor. The GAC selected to assess the above receptors are detailed below in Table 5-1 and Table 5-2.
- 5.1.5 For those determinands included in the analytical suite which do not have corresponding European screening criteria derived from the above sources, UK-specific GAC are utilised. Where these are not available reference is made to other international guidance.
- 5.1.6 Leachate testing is undertaken on soil samples in the laboratory by vigorous mixing of soil and water to ascertain the degree to which contaminants in soil may leach into the dissolved phase. The process represents a 'worst case' scenario as the vigorous laboratory process would not be expected to be replicated on site either during construction or operation. As such, the leachate testing results generally provide an over estimation of the true leachability of contaminants from soils. The exception is for volatile organic compounds (VOCs), which may volatilise and be lost during the leachate preparation process, as such leachate results for VOCs should be treated with caution.

5.2 Analytical Results

- 5.2.1 The results of the screening against relevant GACs are summarised in Table 5-1 and Table 5-2. Results are provided in full in Appendix 2 (Geotechnics Factual Report Appendices 9 and 10).
- 5.2.2 For leachate analysis the following determinands were not detected above laboratory reporting limits include:
- Aliphatic petroleum hydrocarbons fractions - C6-C8, C8-C10, C10-12 and C12- C16; and
 - Aromatic petroleum hydrocarbon fractions – C5-C7, C7-C8, C8-C10 and C10-C12.
- 5.2.3 For groundwater the following determinands were not detected above laboratory reporting limits include:
- Aliphatic petroleum hydrocarbons fractions - C5-C6, C6-C8, C8-C10, C10-12, C12- C16, C21-C35 and C35-C44;
 - Aromatic petroleum hydrocarbon (all fractions);
 - Benzene, Toluene, Ethylbenzene, p & m-xylene, o-xylene (BTEX);

- Nine PAHs (acenaphthylene, anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, Dibenzo(a,h)anthracene, Benzo(a)anthracene and benzo[g,h,i]perylene);
- Phenols;
- Methyl Tertiary Butyl Ether (MTBE);
- Volatile Organic Compounds not mentioned in Table 5.2; and
- Semi-volatile Organic Compounds.

Table 5-1 Summary of Chemical Test Results on Soil Leachate Samples

Contaminant	No. of Samples	Environmental Quality Standards (µg/l)	Drinking Water Standards (µg/l)	Number of Exceedances of GAC	Minimum Concentration (µg/l)	Maximum Concentration (µg/l), location and depth (m)
Metals						
Antimony	35	NC	5	0	<MRL	4.9 (BH104 at 0.20m)
Arsenic	35	50	10	0	0.18	4.6 (BH101 at 0.20m)
Barium	15	NC	1,300	0	3.1	22 (IP100 at 1.20m and IP101 at 0.20m)
Boron (water soluble)	35	2,000	1,000	0	<MRL	49 (TP102, 0.70m)
Cadmium	35	NC	5	0	<MRL	0.17 (TP102 at 0.50m)
Chromium III	35	4.7	50	7 (EQS)	<MRL	6.4 (TP101 at 0.25m)
Chromium VI	35	3.4	NC	2 (EQS)	<MRL	27 (BH104 at 0.20m)
Copper	35	1	2,000	30 (EQS)	<MRL	8.1 (BH104 at 0.20m)
Lead	35	1.2	10	2 (DWS) 23(EQS)	<MRL	30 (BH104 at 0.20m)
Mercury	35	0.07	1	2 (EQS)	<MRL	0.15 (BH104 at 0.15m)
Nickel	35	4	20	0	<MRL	2.6 (TP100 at 1.20m)
Selenium	35	NC	10	0	<MRL	1.5 (BH101 at 6.00m)
Zinc	35	10.9	5,000	3 (EQS)	<MRL	32 (TP102 at 0.50m)
Vanadium	21	20 (0-200mg/l CaCO3)	NC	0	<MRL	14 (BH101 at 0.20m)
Total Petroleum Hydrocarbons (TPH)						
Aliphatic C5-C6	35	NC	15,000	0	<MRL	35 (BH104 at 0.20m)
Aliphatic C21-C35	35	NC	NC	N/A	<MRL	300 (TP104 at 1.50m)
Aliphatic C35-C44	35	NC	NC	0	<MRL	2.4 (TP104 at 1.50m)

Contaminant	No. of Samples	Environmental Quality Standards (µg/l)	Drinking Water Standards (µg/l)	Number of Exceedances of GAC	Minimum Concentration (µg/l)	Maximum Concentration (µg/l), location and depth (m)
Aliphatic C10-C44	35	NC	300	0	<MRL	270 (TP104 at 1.50m)
Aromatic C12-C16	35	NC	90	0	<MRL	3.3 (TP04 at 1.50m)
Aromatic C16-C21	35	NC	90	0	<MRL	19 (TP04 at 1.50m)
Aromatic C21-C35	35	NC	90	1 (DWS)	<MRL	190 (TP04 at 1.50m)
Aromatic C35-C44	35	NC	NC	0	<MRL	28 (TP104 at 1.50m)
Polyaromatic Hydrocarbons (PAH)						
Naphthalene	35	2	NC	0	<MRL	0.17 (BH101 at 0.50m)
Acenaphthylene	35	NC	NC	0	<MRL	0.07 (TP102 at 0.50m)
Acenaphthene	35	NC	NC	0	<MRL	0.04 (TP100 at 1.20m)
Fluorene	35	NC	NC	0	<MRL	0.03 (TP100 at 1.20m)
Phenanthrene	35	NC	NC	0	<MRL	0.16 (TP102 at 0.50m)
Anthracene	35	NC	NC	0	<MRL	0.06 (TP102 at 0.50m)
Fluoranthene	35	0.12*	NC	4 (EQS)	<MRL	0.47 (TP102 at 0.50m)
Pyrene	35	NC	NC	0	<MRL	0.42 (TP102 at 0.50m)
Benzo(a)pyrene	35	0.27*	0.01	13 (DWS) 1 (EQS)	<MRL	0.34 (TP102 at 0.50m)
Notes: MRL- Method Reporting Limit NC- No Criteria N/A- Not Applicable						

Table 5-2 Summary of Groundwater Chemical Test Results

Contaminant	No. of Samples	Environmental Quality Standards (EQS)(µg/l)	Drinking Water Standards (DWS)(µg/l)	Number of Exceedances of GAC	Minimum Concentration (µg/l)	Maximum Concentration (µg/l) and location
Metals						
Antimony	7	NC	5	0	0.27	1.6 (BH103)
Arsenic	7	50	10	0	0.3	0.84 (BH103)
Barium	7	NC	1,300	0	16	86 (BH101)
Boron (water soluble)	7	2,000	1,000	0	<MRL	54 (BH100)
Cadmium	7	NC	5	0	<MRL	0.12 (BH101)
Chromium III	7	4.7	50	0	<MRL	6.1 (BH103)
Chromium VI	7	3.4	NC	0	<MRL	<MRL
Copper	7	1	2,000	1 (EQS)	1.2 (Bioavailable concentration – 0.09)	6.3 (Bioavailable concentration – 1.22) (BH102 and BH103 – maximum bioavailable concentration)
Lead	7	1.2	10	0	<MRL(Bioavailable concentration – <MRL)	1.2 (Bioavailable concentration – 0.60) (BH101)
Mercury	7	0.07	1	0	<MRL	0.03 (BH101)
Nickel	7	4	20	0	<MRL (Bioavailable concentration 0.04)	4.1 (Bioavailable concentration – 0.31) (BH101)
Selenium	7	NC	10	0	0.28	3 (BH105)
Vanadium	7	20 (0-200mg/l CaCO3)	NC	0	<MRL	8.3 (BH103)
Zinc	7	10.9	5,000	3 (EQS)	1.3 (Bioavailable concentration – 0.95)	65 (Bioavailable concentration – 35.41)(BH106)

Contaminant	No. of Samples	Environmental Quality Standards (EQS)(µg/l)	Drinking Water Standards (DWS)(µg/l)	Number of Exceedances of GAC	Minimum Concentration (µg/l)	Maximum Concentration (µg/l) and location
Polyaromatic Hydrocarbons (PAH)						
Naphthalene	7	2	NC	0	<MRL	0.11 (BH100)
Acenaphthene	7	NC	NC	0	<MRL	0.01 ((BH100, BH104 and BH106)
Fluorene	7	NC	NC	0	<MRL	0.01 (BH106)
Phenanthrene	7	NC	NC	0	<MRL	0.02 (BH104)
Fluoranthene	7	0.12*	NC	0	<MRL	0.03 (BH106)
Pyrene	7	NC	NC	0	<MRL	0.04 (BH106)
Benzo(a)anthracene	7	NC	NC	0	<MRL	0.01 (BH106)
Total Petroleum Hydrocarbons						
Aliphatic C10 – C44	7	NC	NC	0	<MRL	16 (BH100)
Aliphatic C16 – C21	7	NC	NC	0	<MRL	15 (BH100)
Volatile Organic Compounds (VOC)						
Chloroform	3	2.5	300	3 (EQS)	3	9 (BH106)
Bromodichloromethane	3	NC	NC	0	<MRL	5 (BH106)
Dibromochloromethane	3	NC	NC	0	<MRL	2 (BH106)

Notes:

The following criteria have been used to select GAC:

- G1 – Hazardous substances in groundwater for waterbodies at 'High' WFD status: UKTAG Technical Report on Groundwater Hazardous Substances Sept 2016 plus accompanying Confirmed Hazardous Substances List (January 2018)
- G2 – Non-hazardous substances in groundwater and waterbodies not at 'High' WFD status: WFD Threshold Values (TVs) for 'Good' Status. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- S1 – Priority substances in surface water and selected (other determinands to which this policy relates): 2013/39/EU: Priority Substances in the Field of Water Policy Directive and 2008/105/EC: Environmental Quality Standards in the Field of Water Policy Directive
- S2 – Specific and other pollutants in surface water: The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 or where not available EA EQSs to be utilised in surface water risk assessments as part of environmental permit applications and WFD assessments of works in coastal and transitional waters in England.
- * -For Fluoranthene and PAHs, the biota EQS refers to crustaceans and molluscs. For the purpose of assessing chemical status, monitoring of Fluoranthene and PAHs in fish is not appropriate. An alternative biota taxon, or another matrix, may be monitored instead, as long as the EQS applied provides an equivalent level of protection. The nearest receiving water to site is unlikely to be utilised for crustacean and molluscs production for human consumption.
- Bioavailable concentrations of copper, lead, nickel, and zinc have been calculated using the Water Framework Directive mBAT tool.
- NC – No criteria available
- N/A – Not applicable
- MRL – Method reporting limit

5.3 Controlled Waters Summary

Leachate

- 5.3.1 Exceedances of screening criteria do 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. Contaminant concentrations in soil leachate completed on 35 samples have been compared to the Drinking Water Standards (DWS) and to the Environmental Quality Standards (EQS).
- 5.3.2 One exceedance of the DWS for aromatic C21-C35 (90 µg/l) was identified within leachate obtained from a sample of made ground at TP104 at 1.50m bgl (190 µg/l). The concentrations for total petroleum hydrocarbons in other samples did not exceed the corresponding EQS or DWS. A strong hydrocarbon odour was noted during the ground investigation at TP104 at 1.50m bgl.
- 5.3.3 The following metals were recorded in leachate samples exceeding the EQS or DWS, associated with the made ground:
- Lead (10 µg/l) exceeded the DWS in two samples at BH104 at 0.2m bgl (30 µg/l) and at 2m bgl (12 µg/l) and exceeded the EQS in a total of 23 samples from the Made Ground with the exception of BH102 at 1.00m bgl.;
 - Chromium III (4.7 µg/l) exceeded the EQS in seven samples in the trial pits at TP100 at 1.20m (6.3 µg/l), TP101 at 0.25m (6.3 µg/l), TP101 at 0.90m (5.5 µg/l), TP102 at 0.50m (5.4 µg/l), TP102 at 0.70m (5.7 µg/l), TP103 at 0.40m (5.0 µg/l) and IP100 at 1.20m (4.8 µg/l);
 - Chromium VI (3.4 µg/l) exceeded the EQS in two samples at TP100 at 0.05m (15 µg/l) and BH104 at 0.20m (27 µg/l);
 - Copper (1 µg/l) exceeded the EQS in a total of 30 samples from the Made Ground with the exception of BH104 at 5.00m bgl and BH106 at 5.00m bgl;
 - Mercury (0.07 µg/l) exceeded the EQS from one sample at BH104 at 0.2m bgl (0.15 µg/l);
 - Zinc (10.9 µg/l) exceeded the EQS in three samples at TP102 at 0.50m (32 µg/l), TP102 at 0.70m (17 µg/l) and 0.20m (13 µg/l);
 - Fluoranthene (0.12 µg/l) exceeded the EQS in a total of 4 samples with the maximum recorded in TP102 at 0.50m bgl (0.47 µg/l); And
 - Benzo(a)pyrene (0.27 µg/l – EQS and 0.01 – DWS) exceeded the EQS in one sample and DWS in a total of 13 samples with the maximum recorded in TP102 at 0.50m bgl (0.34 µg/l).
- 5.3.4 EQS exceedances for lead, copper and zinc are based on conservative values assuming 100% of the recorded concentrations are bioavailable if leached into the nearest surface water. As no surface water features have been identified in the vicinity of the site these exceedances are therefore not thought to represent an unacceptable risk.

Groundwater

- 5.3.5 No exceedances were recorded for the DWS of any contaminant for the seven obtained groundwater samples.
- 5.3.6 Exceedances of the EQS screening criteria for metals were as follows;
- Copper of 1 µg/l in one location (BH103 – 1.22 µg/l Bioavailable copper); and
 - Zinc of 10.9 µg/l in three locations (BH102 – 11.34 µg/l, BH104 – 16.24 µg/l and BH106 35.42 µg/l).
 - Chloroform exceeded the EQS of 2.5 µg/l in three locations (BH104 - 3 µg/l, BH105 - 7 µg/l and BH106 - 9 µg/l).

- 5.3.7 Exceedances of copper, zinc, fluoranthene and chloroform within the groundwater do not present an unacceptable risk to the nearest surface water feature due to the distance to the nearest surface water feature to site; a pond 230m south east and then the River Gwenfro located 328m southwest.
- 5.3.8 As above the EQS for fluoranthene is a conservative assessment and a screening value of 0.12 µg/l is sufficient therefore there are no exceedances within the groundwater samples.

Discussion

- 5.3.9 No exceedances of DWS were recorded within any groundwater samples across the site therefore the underlying groundwater does not represent an unacceptable risk to current or future human consumption.
- 5.3.10 Within the leachate analysis one exceedance was recorded exceeding the DWS in TP104 at 1.50mbgl from Made Ground for aromatic C21-C35 however no aromatic C21-C35 was detected within the groundwater samples therefore this contaminant does not appear to have impacted groundwater, potentially due to the presence of an aquiclude forming a barrier between the impacted material within the Made Ground and the underlying groundwater within the Glaciofluvial Sheet Deposits. TPH was recorded below the MRL in all the groundwater samples with the exception of BH100 in the far north west of the site which recorded a concentration of 15 µg/l Aliphatic C16-C21.
- 5.3.11 A total of 13 exceedances of the EQS and DWS were recorded of benzo(a)pyrene within the leachate sampling however benzo(a)pyrene was below the level of detect within all groundwater samples.

6. GROUND GAS ASSESSMENT

6.1 Assessment Approach

- 6.1.1 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 gases can present a hazard to site occupants and property as result of flammable / explosive hazards, physiological effects, odour and effects on vegetation.
- 6.1.2 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.
- 6.1.3 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 1.

6.2 Ground Gas Monitoring Results

- 6.2.1 Potential ground gas sources at or in the vicinity of the site, and subject to assessment comprise:
- Potential Source 1: Made Ground
- 6.2.2 Coal seams are noted to be present underlying the site however at the shallowest depth of 322m bgl these would not represent a source of potential ground gas.
- 6.2.3 Six rounds on the Floodlight Ground Investigation (BH100, BH101, BH102, and BH103) on the 11 November, 16 November, 24 November, 30 November, 07 December and 12 December 2022. Six ground gas monitoring rounds have been undertaken on wells BH104, BH105, and BH106, installed during this investigation) on the 14 March and 20 March, 29 March, 04 April, 11 April, and the 18 April 2023. A summary of the results is provided in Table 6-1. The ground gas monitoring results are provided in full in the Geotechnics Factual Report Appendix 2.

Table 6-1 Summary of Ground Gas Monitoring Results

Monitoring Well	No. of Monitoring Rounds	Response Zone Strata	Response Zone (mbgl)	Evidence of Contamination	Water Level Range (mbgl)	Atmospheric Pressure during Monitoring (mb)	Steady State Methane Range (% v/v)	Steady State Carbon Dioxide Range (% v/v)	Oxygen (% v/v)	Flow (l/hr)	Range of Volatile Organic Compounds (ppm)
BH100*	6	Glaciofluvial sheet deposits	23.50 to 25.50	None	5.25 – 5.65	978 – 1013	0.0	0.6 – 0.9	16.0 – 20.0	0	0
BH101	6	Glaciofluvial sheet deposits	7.00 to 10.00	None	8.27 – 8.45	978 – 1013	0.0	0.5 – 0.6	19.1 – 19.9	0	0
BH102*	6	Glaciofluvial sheet deposits	12.90 to 15.90	None	9.54– 9.78	978 – 1013	0.0	0.5 – 0.8	19.5 – 20.3	0	0
BH103*	6	Glaciofluvial sheet deposits	13.50 to 15.60	None	8.91 – 11.50	978 – 1013	0.0	0.2 – 0.4	20.1 – 21.1	0	0
BH104 <i>Shallow</i>	6	Made Ground	1.00 – 2.80	None	Dry	994 – 1019	0.0 – 0.2	0.1 – 2.0	18.1 – 22.3	0 – 0.1	0
BH105 <i>Shallow</i>	6	Made Ground	0.50 – 2.00	Ash within Made Ground	Dry	994 – 1019	0.0 – 0.3	0.4 – 1.3	19.0 – 22.2	0 – 0.4	0
BH106 <i>Shallow</i>	6	Made Ground	1.00 – 2.70	None	Dry	994 – 1019	0.0 – 0.2	1.8 – 4.8	15.1 – 19.1	0 – 0.4	0

Monitoring Well	No. of Monitoring Rounds	Response Zone Strata	Response Zone (mbgl)	Evidence of Contamination	Water Level Range (mbgl)	Atmospheric Pressure during Monitoring (mb)	Steady State Methane Range (% v/v)	Steady State Carbon Dioxide Range (% v/v)	Oxygen (% v/v)	Flow (l/hr)	Range of Volatile Organic Compounds (ppm)
BH104 <i>Deep*</i>	6	Glaciofluvial sheet deposits	12.00 -15.00	None	9.66 – 9.70	994 – 1019	0.0 – 0.3	0.2 - 0.6	19.6 - 21.4	0 – 0.2	0
BH105 <i>Deep*</i>	6	Glaciofluvial sheet deposits	12.00 – 15.00	None	9.75 – 9.87	994 – 1019	0.0 – 0.2	0.2 - 0.7	19.6 - 21.3	0 – 0.1	0
BH106 <i>Deep*</i>	6	Glaciofluvial sheet deposits	15.00 -18.00	None	9.93 – 10.00	994 – 1019	0.0 – 0.1	1.1 – 2.0	19.0 - 19.9	0 – 0.1	0

Gas concentrations and flow rates provided as steady state.

* Groundwater table above top of well screen.

Monitoring wells shown in bold font are situated beneath the proposed building footprint.

6.3 Results and Discussion

- 6.3.1 All deep installs (BH100, BH102 – BH106) had water levels that were above the top of the well screens during both monitoring rounds, and have therefore been discounted from this assessment. This was not the case for the shallow monitoring wells installed at BH104 to BH106 beneath the footprint of the proposed Kop Stand development and so can be used in the assessment.

Atmospheric Pressure

- 6.3.2 For the Kop Stand investigation the six monitoring rounds were undertaken during a range of atmospheric pressures (994 mb to 1019 mb). Three rounds were undertaken during periods of relatively low atmospheric pressure (994 to 1001 mb) and three rounds were undertaken during periods of higher atmospheric pressures (1013 to 1019 mb).

Flow Rates

- 6.3.3 A very slight steady flow rate of 0.1 l/hr was detected in BH104, and a slight steady flow rate (<0.1 – 0.4 l/hr) was detected in the shallow monitoring wells BH105 and BH106.
- 6.3.4 The low flow rates recorded over monitoring rounds for the shallow monitoring wells installed in the footprint of the proposed new Kop Stand indicate that the gas generating potential in shallow soils is low.

Methane and Carbon Dioxide

- 6.3.5 The maximum steady methane recorded was 0.3% by volume (v/v) (BH104 to BH106 – shallow wells) in the area of the proposed new Kop Stand.
- 6.3.6 For the shallow monitoring wells installed in the area of the proposed new Kop Stand steady carbon dioxide concentrations ranged from 0.1% to 4.8 v/v. The maximum steady state carbon dioxide recorded was 4.8% v/v in BH106 towards the northeast of the site. These elevated concentrations of carbon dioxide are potentially associated with the underlying Made Ground.

Oxygen

- 6.3.7 Oxygen concentrations varied from 15.0% v/v and 22.3% v/v in the shallow monitoring wells BH104, BH105 and BH106.
- 6.3.8 In all rounds only two incidences of reduced oxygen levels were recorded below 18 % v/v. This was a recording of 15.1% (20 March) and 16% (11 April) in the shallow monitoring well BH106 in the footprint of the proposed Kop Stand. In both cases the reduced oxygen concentrations coincided with the maximum recorded steady carbon dioxide concentrations of 4.8%.

Carbon Monoxide

- 6.3.9 A maximum carbon monoxide concentration of 1ppm was recorded in the shallow monitoring wells installed at BH104 and BH106 for the Kop Stand investigation which is not considered a significant concentration.

Hydrogen Sulphide

- 6.3.10 Hydrogen sulphide was not detected at concentrations above the lower instrument detection limit (<1 ppm) at all locations.

Volatile Organic Compounds (VOCs)

- 6.3.11 During the ground gas monitoring a photo-ionisation detector (PID) was used to screen for the potential presence of VOCs within the monitoring wells. PID readings were recorded below the instrument detection limit in all monitoring results.

Monitoring Frequency

6.3.12 For the Kop Stand investigation six planned monitoring rounds have been completed for the site. Six monitoring rounds have been completed for the monitoring wells installed as part of the floodlights ground investigation. The total number and frequency of monitoring rounds was assessed with reference to guidance provided within BS58576.

6.4 Outcome of Ground Gas Assessment

6.4.1 Details of Ramboll's assessment methodology is presented in Appendix 1 and a discussion of the results is provided below. The risk posed by ground gases has been assessed by calculating a Gas Screening Value (GSV). The worst case GSV has been calculated based on the worst-case scenario, i.e. maximum ground gas concentrations and maximum flow rates applied as relevant to each of the potential sources; as summarised in Table 6-2. The GSV is used to identify the relevant characteristic situation (CS).

Table 6-2 Ground Gas Assessment Based on Worst Case Scenario

Worst Case	Flow Rate (l/hr)	CO ₂		CH ₄		Characteristic Situation
		Maximum Steady State Gas Concentration	GSV (l/hr)	Maximum Steady State Gas Concentration (% v/v)	GSV (l/hr)	
Potential Source 1	0.4	4.8	0.0192	0.3	0.0012	CS1

Based on BS8485¹⁰

6.4.2 The GSV for carbon dioxide is taken on a worst-case scenario across the site and was calculated as 0.0192 l/hr which corresponds to 'Characteristic Situation 1' (CS1, very low hazard) in BS8485 which is applicable for industrial/commercial and high-rise residential development.

6.4.3 The GSV for methane is taken on a worst-case scenario across the site and was calculated as 0.0012l/hr which corresponds to 'Characteristic Situation 1' (CS1, very low hazard) in BS8485 which is applicable for industrial/commercial and high-rise residential development.

6.4.4 In summary, in the initial assessment the site is considered to be CS1 (very low hazard) due to low steady flow rates and no significant concentrations of gas.

6.4.5 The design of the proposed new Kop Stand and any other new buildings on site will need to take into account the findings of this ground gas risk assessment and will not need to consider the incorporation of ground gas protection measures for the proposed use of the site. The requirement (or otherwise) and design of gas protection measures will need to be agreed in consultation with the building control authority prior to construction and implemented in line with guidance provided in BS8485 which includes consideration for the building's construction and use.

6.5 Radon Assessment

6.5.1 No monitoring of radon has been undertaken as part of the ground investigations at the site. However, it should be noted that the site is located within an area where 3-5% of dwellings exceed the radon action level and therefore basic radon protection measures will be required, in

¹⁰ British Standard Institute (2015) Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Building 8485:2015+A1:2019

accordance with BR 211 for new buildings¹¹ and GG 75 for new large buildings. As a minimum this should incorporate the installation of a damp proof membrane to the floor slab, tied into the damp proof course in the walls. Joints in the membrane and any service penetrations through the membrane will need to be sealed.

¹¹ BRE, 2015. BR 211: Radon. Guidance on protective measures for new buildings. By Chris Scivyer.

7. FOUNDATION RISK ASSESSMENT

7.1 Introduction

- 7.1.1 A Foundation Risk Assessment is required in accordance with Environment Agency requirements (see Section 7.4) to establish whether the use of deep foundations for the new Kop Stand and for the floodlights could introduce any potential risks to controlled waters and human health.

7.2 Description of Structure

Kop Stand

- 7.2.1 The general structure of the Kop Stand will consist of numerous piles across the footprint supporting beams and ground bearing slab. These piles will need to support the stand which will include facilities and a canopy. The depth of the piles is anticipated to be 20.0m bgl with 1.0m deep pile caps.

Floodlights

- 7.2.2 Currently it is anticipated the floodlights will be installed on concrete slabs supported on piles to an unknown depth but for this assessment assumed to be 20m bgl with pile caps to 2.0m bgl.
- 7.2.3 Full foundation details will be delivered by the piling contractor this report will need updating if the final foundation design differs significantly from these assumptions.

7.3 Foundation Type

- 7.3.1 It is understood the Kop Stand will be founded on piled foundations connected by concrete pile caps to 1.0m bgl. There will be more than 50 No.450mm diameter Continuous Flight Auger (CFA) piles across the footprint of the new stand to a depth of 20m bgl.
- 7.3.2 It is assumed the floodlights will also be supported by Continuous Flight Auger (CFA) piles but situated upon 2.0m bgl pile caps, however these design has not been confirmed at this stage.
- 7.3.3 Table 7.1 provides a more detailed explanation of the piling methods being employed at the site.

Table 7-1 Description of Piling Techniques

Piling Technique	Description	Potential Hazards
CFA -Piles	This non-displacement piling method involves the drilling of an auger with a hollow stem (temporarily plugged) into the ground. Once the design depth is reached, concrete is pumped through the hollow stem of the auger while the auger is extracted at a controlled rate, keeping the end of the auger embedded into the concrete, maintaining a positive pressure throughout the process. Once the full length of the pile is concreted a reinforcement steel cage is pushed into the fluid concrete to provide additional strength.	The use of non-displacement piles has the potential to bring contaminated soil arisings to the surface. Soil arisings will require management and either disposal off-site or re-use on-site as set out in the earthworks specification and / or the Materials Management Plan (MMP) if in place. Segregation of this material from the vicinity of each pile location during piling will minimise the potential for cross contamination of arisings and the creation of additional waste that will need controlled disposal. The progression of CFA piles relies on the retention of soil on the augur flights to support the surrounding soil and prevent collapse or migration outwards of soil. The potential for creation of a temporary pathway for groundwater flow around the auger is limited with this method, and should one occur, it would likely be short lived (in the region of

Piling Technique	Description	Potential Hazards
		minutes) and subsequent concreting of the pile and close up of soil due to soil stresses would close the pathway.

7.4 Risk Assessment

7.4.1 The assessment of piling risks has been carried out with due regard to the following Environment Agency documents:

- Piling into Contaminated Sites¹²;
- Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention NC/99/73¹³; and
- Piling in Layered Ground: Risks to Groundwater and Archaeology¹⁴.

7.4.2 In particular this risk assessment makes reference to a number of generic pollution scenarios detailed within NC/99/73 which are summarised in Table 7.2.

Table 7-2 Summary of generic pollution scenarios detailed with NC/99/73

Scenario	Detail
1	Creation of preferential pathways through a low permeability layer (an aquitard) to allow potential contamination of an aquifer and/or surface water feature
2	Creation of preferential pathways, through a low permeability surface layer, to allow migration of landfill gas, soil gas or vapours to surface
3	Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface
4	Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials
5	The driving of solid contaminants down into an aquifer during pile driving
6	Contamination of groundwater, and subsequently, surface waters by wet concrete, cement paste or grout
+	Any other relevant pollution scenarios

7.4.3 Consideration is given to whether each scenario is significant in the context of the proposed piling method at the site. Each of the risks for the site-specific piling methods are then assessed in terms of the likelihood and the severity of the consequence using the following criteria in Table 7.3 & Table 7.4.

Table 7-3 Definition of severity

Severity	Criteria
High	Significant pollutant linkage which would cause deterioration of water quality or significant risks to human health in the long term.
Medium	Pollutant linkage which could result in deterioration of water quality or risks to human health in the long term or cause a short-term pollutant linkage restricted to the duration of piling.
Low	Any pollutant linkage caused would not significantly affect water quality or risks to health.

¹² Environment Agency (2002) Piling into Contaminated Sites.

¹³ Environment Agency (2001) Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination Guidance on Pollution Prevention NC/99/73.

¹⁴ Environment Agency (2014) Piling in Layered Ground: Risks to Groundwater and Archaeology SC020074.

Table 7-4 Definition of likelihood

Likelihood	Criteria
High	Would cause a pathway to be created.
Medium	May cause a pathway to be created, but if it was realised, would not be likely to represent a significant risk.
Low	Would be unlikely to cause a pollutant linkage, but if it was realised, would not be likely to represent a significant risk.

7.4.4 The severity and likelihood classifications are then used to provide an overall risk, as detailed below in Table 7.5.

Table 7-5 Risk Matrix

		Severity		
		High	Medium	Low
Likelihood	High	Very High	High	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Very Low

7.4.5 An assessment of the risks associated with the proposed piling works is provided in Table 7.6. The assessment is based on site-specific conditions and known levels of contamination plus potential for encountering unexpected contamination.

Table 7-6 Foundation Risk Assessment for CFA Piling

Site-Specific Pollution Scenario	Activity	Source (S) Pathway (P) Receptor (R)			Severity	Likelihood	Risk Assessment	Comments/Mitigation Measures
1: Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.	CFA piles	S	Potential contaminated soils / perched groundwater		Medium	Low	Low	The use of CFA piles minimises the risk of vertical pathway creation and is a method generally accepted by the Environment Agency for contaminated sites where important aquifers lie beneath. Visual or olfactory evidence of contamination was only noted at one location TP104 1.0m to 1.80m bgl during the ground investigation but no piling is planned for this area. However leachable concentrations of metals and PAHs were identified above the DWS and EQS assessment criteria within the Made Ground. Groundwater in the Glaciofluvial Sheet Deposits identified marginal exceedances of EQS for metals, PAHs and chloroform. Ground conditions identified granular layers within Glaciofluvial Sheet Deposits that could potentially be water bearing strata. However, these are laterally discontinuous, confined between cohesive layers and unlikely to migrate vertically to the groundwater.
		P	Vertical pathway created by CFA piles					
		R	Secondary A Aquifer (Glaciofluvial Sheet Deposits)					
2: Creation of preferential pathways through a low permeability surface layer, allowing migration of landfill gas, soil gas or contaminant vapours to the surface.	CFA piles	S	Underlying geology		Medium	Negligible	N/A	No landfills or organic rich soils were identified during the ground investigation in the areas of piling. No significant ground gas concentrations recorded during ground gas monitoring therefore, the likelihood of this pathway is negligible and therefore not considered a risk. The enabling works contractor and any subcontractors are required to have appropriate safe working practices and health and safety measures in place during works e.g. personal protective equipment (PPE), (respiratory protective equipment) RPE and confined spaces entry systems etc.
		P	Pathway created by CFA piles					
		R	Human health and buildings					
3: Direct contact of site workers and others with contaminated soil arising that have been brought to the surface.	CFA piles	S	Potential contaminated soils / perched groundwater		Low	Low	Very Low	There were no exceedances of the assessment criteria for a commercial land use. Site workers will require appropriate PPE; this will reduce the risk to negligible. Site activities are to be managed and controlled. The Land Quality Method Statement (LQMS -which details procedures for managing contaminated soils, materials and unexpected contamination) will be adhered throughout the project.
		P	Soils brought to the surface					

Site-Specific Pollution Scenario	Activity	Source (S) Pathway (P) Receptor (R)	Severity	Likelihood	Risk Assessment	Comments/Mitigation Measures
4: Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of materials.	CFA piles	R Site workers				
		S Natural soil conditions such as elevated sulphates	Low	Low	Very Low	All samples except one (TP101 at 0.25m bgl – 1,500mg/l) had water Soluble Sulphate concentrations below the 500mg/l threshold for DS1 concrete classification set out in the BRE SD1 Part1 3 rd Edition. However the location of TP101 is located outside of the building footprint.
		P Contact				
		R Construction Materials				An assessment of the ground and groundwater aggressivity will be confirmed by the Piling Contractor. This will inform the appropriate concrete design class/ specification required for the site and will mitigate risk to the built environment.
5: The driving of solid contaminants down into an aquifer during pile driving	CFA piles	S Potential contaminated soils / perched groundwater	Low	Low	Very Low	The severity is low due to the limited contamination identified in the area of the proposed foundations.
		P Pathway created by piles				The anticipated volume of material dragged down is expected to be minimal owing to the nature of the method used.
		R Glaciofluvial Sheet Deposits Secondary A Aquifer				
6: Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste, grout or polymer	CFA piles	S Construction Materials	Medium	Low	Low	Concrete deliveries and the wash out of concrete mixers will be managed at the site in accordance with a Construction stage Environmental Management Plan which will ensure that wash out water containing cement / concrete is not discharged to ground or allowed to flow into surface water features though unlikely due to the distance of such features from site. Concrete used in the construction of the piles will need to be of the right consistency to (i.e. of sufficient strength) to hold the bore open so is unlikely to be overly wet, however, the release of concrete in groundwater cannot be ruled out. Groundwater beneath the site will be limited to laterally discontinuous layers of granular glacial deposits at depths of ~10m bgl within the Glaciofluvial Sheet Deposits (Secondary A aquifer). On this basis the overall risk is considered to be low.
		P Pathway created by piles				
		R Glaciofluvial Sheet Deposits Secondary A Aquifer				

8. SOURCE-PATHWAY-RECEPTOR RISK ASSESSMENT

8.1 Proposed Development Considerations

8.1.1 It is understood there will be two stages of development:

- Construction of new flood lighting which is understood will involve concrete pads on piles installed using the continuous flight auger method; and
- Construction of a new Kop Stand which will encompass the majority of the site to the east. It is understood the stand will utilise continuous flight auger piles to a depth of 20m bgl. There will be a public realm area to the east of the Kop Stand which will include an area of public open space covered by hardstanding with raised planters and sunken tree pits. Currently facilities planned for within the Kop Stand excluding standing for spectators will include club offices, community and hospitality spaces (including banqueting) and a club shop. The drainage strategy for the Kop development is to be infiltration based.

8.2 Updated Conceptual Site Model

8.2.1 The information presented in the previous sections of this report has been collated and evaluated to refine the preliminary conceptual site model for the site.

8.3 Qualitative Risk Assessment

The potential contamination linkages which were identified at within the conceptual site model in the PRA stage as posing a potentially risk are considered further by reassessment based on the ground investigation findings.

8.3.1 Table 8.1 forms a qualitative risk assessment.

8.3.2 Potential pollutant linkages are identified using the source-pathway-receptor framework detailed in Appendix 1. An assessment of the potential of each linkage is then made by consideration of the likely magnitude and mobility of the source, the sensitivity of the receptor and nature of the migration/exposure pathways between them.

8.3.3 This qualitative risk assessment has been undertaken by definition of risk categories in accordance with NHBC and EA guidance, further details of which are provided in Appendix 1.

8.3.4 Table 8-1 summarises the updated assessment of PCLs and risk categories associated with the proposed development as assessed following interpretation of the results of the ground investigation.

Table 8-1 Ground Contamination Risk Assessment – Updated Conceptual Site Model (CSM)

Potential Contaminants	Potential Pathways	Potential Receptors	Risk of Pollutant Linkage	Overall Risk Rating
Onsite				
Potential for made ground and localised spills (oils / fuels) from vehicles. No significant contamination sources identified from current or historical site uses.	Dermal contact / ingestion	Future users	No exceedances of human health screening criteria for commercial end use. Additionally, the site including the areas for the floodlights will mainly comprise hardstanding, limiting any potential pathways.	Very Low
	Dermal contact / ingestion	Construction and future maintenance workers	No exceedances of human health screening criteria for commercial end use however construction workers should use appropriate safe working practices and health and safety measures during works (e.g. personal protective equipment (PPE) and respiratory protective equipment (RPE)).	Very Low
			Asbestos was encountered in one location <0.001% however due to the nature of asbestos it is possible to exist in discrete pockets construction workers should be made aware of the potential risk.	
	Inhalation of gas / vapours	Future users	No significant concentrations of ground gas encountered within shallow soils and low flow rates recorded, therefore no gas protection measures would be required. The site is located within an area where 3-5% of dwellings exceed the radon action level and radon protection measures may be required. This will be determined by the local authority.	Low
	Inhalation of gas / vapours	Construction and future maintenance workers	No significant concentrations of ground gas encountered and low flow rates recorded, however construction workers should use appropriate safe working practices and health and safety measures during works (e.g. personal protective equipment (PPE) and respiratory protective equipment (RPE)).	Low

	Leaching to groundwater & groundwater flow	Groundwater within the Secondary A aquifer in the superficial Glaciofluvial Sheet Deposits and Sandstone bedrock.	Leachable concentrations exceeding the DWS for aromatic hydrocarbons (C21-C35) identified in TP104 at 1.50m bgl. However, no exceedances have been observed within the groundwater, suggesting no pathway to groundwater. Piling activities are unlikely to create a pathway for contaminant migration to groundwater. The proposed design will be covered in hardstanding reducing the infiltration of rainwater and subsequent leaching of contaminants.	Very Low
	Surface water runoff	Surface water as controlled water.	Low mobility of contaminants identified, no perched groundwater observed and the nearest surface water feature is located at distance from the site.	Very Low
	Direct contact	Buildings and services	No significant contamination identified at the site therefore risk to future buildings is considered to be low. Water soluble sulphate recorded at the site is low except at TP101 at 0.25m bgl within the Made Ground where 1,500 mg/l was observed. However this location is outside of the building footprint so is unlikely to be an issue.	Low
Off site				
Potential current and historical off-site contamination sources in the vicinity of the site including: - Various railway features including tracks, sidings, goods shed / depot. - Scrapyard - Various works, depots, warehouses	Groundwater flow	Underlying the groundwater within Glacial Till deposits.	Exceedances of chloroform within groundwater above the EQS however no on-site sources have been identified. Therefore it is assumed to be from an offsite source. Due to the underlying clay acting as an aquiclude metals within groundwater are also likely to be from an offsite source or represent existing background levels of naturally occurring contaminants.	Low
	Inhalation of gas / vapours	Future site users	No significant ground gas or flow identified during the ground gas monitoring therefore no impact is	Very low

Garages and petrol stations			expected from any potential sources from nearby sites.	
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8.4 Climate Change Considerations

The UK Government and devolved administrations have produced climate change adaptation programmes, including plans for both mitigating and adapting to climate change. SDGs support the development of Sustainable Cities and Communities (SDG No. 11), Clean Water and Sanitation (SDG No.6), sustainable ecosystems (SDG No.14. Life below Water and SDC No. 15 Life on Land). It is therefore important to recognise how changes in weather/season/climate could affect the ground conditions that were encountered during the investigation.

Climate change projections¹⁵ demonstrate that in the UK the following conditions are expected to result from future climate change: drier and hotter summers, wetter and milder winters, a higher frequency of intense rainfall periods and sea level rise. The following are considered relevant to the assessment:

- Drier, hotter weather – would lower the water table but contaminants could come more concentrated however unlikely to affect the site as contaminants in groundwater not a problem.
- Wetter weather – could increase groundwater table and therefore dilute contaminants however may cause increased leaching. However unlikely to affect the site as will be covered in hard standing.
- Higher water table – mobilisation of contaminants which are currently within the unsaturated zone, mobilisation through pathways such as service/drainage routes that previously were above the water table, new groundwater-surface water interaction, introduction of new GWDTEs
- Greater fluctuation of water table – increased NAPL smear zones, changes to groundwater discharge locations and flow directions

Based on the above considerations, the effects of climate change are not likely to alter the findings of the risk assessment.

¹⁵ Meteorological Office UK (2018). UKCP18 Land Projections: Science Report, Updated March 2019.

9. PRELIMINARY WASTE ASSESSMENT

9.1 Methodology

9.1.1 The assessment has been undertaken using available soil chemical data and HazWasteOnline, an internet based tool for classifying waste. The software utilises EA guidance and European regulations to classify samples in line with current requirements. Further details of the waste classification methodology are provided in Appendix 1. The HazWasteOnline output sheets are provided in Appendix 4.

9.2 Soils Assessment

9.2.1 Samples collected during the ground investigations were combined and entered into the HazWasteOnline assessment tool.

9.2.2 These comprised samples of:

- Thirteen samples from the Glaciofluvial Sheet Deposits
- Twenty-eight samples from the Made Ground

9.2.3 The results including the 24 Waste Acceptance Criteria (WAC) results undertaken are shown in Table 9-1.

9.2.4 The Hazardous Waste (England and Wales) Regulations¹⁶ requires that any waste having an asbestos content greater than 0.1 % w/w be classified as Hazardous Waste. Any waste with a total asbestos content of less than 0.1 % w/w can be classified as non-hazardous waste, unless there are other contaminants present which would make the waste hazardous. Details of asbestos testing are provided in Table 9-1.

9.2.5 Asbestos was only recorded in one location at IP101 at 0.2m bgl however was below the <0.001% and therefore classified as non-hazardous.

Table 9-1 Summary Preliminary Waste Classification Assessment

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties	Asbestos (x/✓)	Landfill Type Based on WAC Results	Waste Assessment Outcome
Made Ground						
BH100	0.15	Not hazardous	N/A	x	Inert	Inert
BH100	0.40	Not hazardous	N/A	x	Inert	Inert
BH101	0.20	Not hazardous	N/A	x	N/A	Non-hazardous
BH101	0.50	Not hazardous	N/A	x	Inert	Inert
BH102	0.10	Not hazardous	N/A	x	N/A	Non-hazardous
BH102	0.50	Not hazardous	N/A	x	N/A	Non-hazardous
IP100	0.30	Not hazardous	N/A	x	N/A	Non-hazardous
IP100	0.80	Not hazardous	N/A	x	Non-hazardous	Non-hazardous
IP100	1.20	Not hazardous	N/A	x	N/A	Non-hazardous

¹⁶ UK Statutory Instruments (2005) Hazardous Waste (England and Wales) Regulations, No. 894

Wrexham Kop Development

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties	Asbestos (x/✓)	Landfill Type Based on WAC Results	Waste Assessment Outcome
IP101	0.20	Not hazardous	N/A	✓ <0.001%	N/A	Non-hazardous
IP101	1.00	Not hazardous	N/A	x	Inert	Inert
IP101	1.20	Not hazardous	N/A	x	N/A	Non-hazardous
TP100	0.05	Not hazardous	N/A	x	Inert	Inert
TP100	1.20	Not hazardous	N/A	x	Inert	Inert
TP101	0.25	Not hazardous	N/A	x	Non-hazardous	Non-hazardous
TP101	0.90	Not hazardous	N/A	x	Inert	Inert
TP102	0.50	Not hazardous	N/A	x	Non-hazardous	Non-hazardous
TP102	0.70	Not hazardous	N/A	x	Non-hazardous	Non-hazardous
TP103	0.20	Not hazardous	N/A	x	Inert	Inert
TP103	0.40	Hazardous	Zinc	x	Stable non-reactive hazardous	Stable non-reactive hazardous
TP104	0.25	Not hazardous	N/A	x	Non-hazardous	Non-hazardous
TP104	1.50	Hazardous	TPH	x	Stable non-reactive hazardous	Stable non-reactive hazardous
BH106	0.20	Not hazardous	N/A	x	N/A	Non-hazardous
BH106	2.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH105	0.20	Not hazardous	N/A	x	N/A	Non-hazardous
BH105	1.00	Not hazardous	N/A	x	Inert	Inert
BH104	0.20	Not hazardous	N/A	x	N/A	Non-hazardous
Natural Strata – Glaciofluvial Sheet Deposits						
BH100	1.00	Not hazardous	N/A	x	Inert	Inert
BH100	3.00	Non-hazardous	N/A	x	N/A	Non-hazardous
BH101	1.00	Not hazardous	N/A	x	Inert	Inert
BH101	2.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH101	4.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH101	6.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH102	1.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH012	3.00	Not hazardous	N/A	x	N/A	Non-hazardous

ID	Depth (mbgl)	Waste Classification (European Waste Management Regulations)	Hazardous Properties	Asbestos (x/✓)	Landfill Type Based on WAC Results	Waste Assessment Outcome
BH102	5.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH104	2.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH014	5.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH106	3.00	Not hazardous	N/A	x	Inert	Inert
BH106	5.00	Not hazardous	N/A	x	N/A	Non-hazardous
BH106	16.00	Not hazardous	N/A	x	N/A	Non-hazardous

9.2.6 Based on the HazWasteOnline Assessment the majority of the waste is classified as non-hazardous with the exception of TP103 at 0.40m bgl for zinc and TP104 at 1.50m bgl for TPH. Generally, as the zinc exceedance is an outlier it is recommended the majority of the site is classified as non-hazardous. Due to olfactory evidence of contamination in TP104 this material will be classified as hazardous if requiring removal from site. A watching brief should be in place if this material is to be excavated to ensure it has been removed entirely.

9.3 Discussion / Summary

- 9.3.1 Based upon the information available, the overall waste classification of the soils underlying the site is **non-hazardous**.
- 9.3.2 Of the 23 WAC testing results 11 were classified as either hazardous or stable non-reactive non-hazardous due to total organic carbon content. The remaining samples are classified as inert.
- 9.3.3 Note that the indicative waste classifications provided as a part of this assessment should be confirmed by any receiving facility prior to disposal, under Duty of Care, following discussions with the producer of the waste. Additional chemical testing and / or WAC analysis may be required prior to disposal.
- 9.3.4 Should the reuse of site won materials be considered suitable, consideration should be given to the risk to human health and the environment that any such material may pose as part of its new use. This could be under (for example) the provisions of the CL:AIRE Definition of Waste: Development Industry Code of Practice (DoW:CoP)¹⁷.

¹⁷ CL:AIRE (2011) The Definition of Waste: Development Industry Code of Practice Version 2. ISBN 978-1-905046-23-2

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

- 10.1.1 The GQRA is based on a site investigation strategy prepared by Ramboll. The strategy did not identify any point sources of contamination but provided sufficient coverage across the site to assess any potential risks. The strategy considered potential contaminant migration pathways and likely environmental receptors, which informed the design of the investigation.
- 10.1.2 The site investigation was designed by Ramboll and completed by Geotechnics Ltd. The site investigation comprised seven boreholes (6 cable percussion and one open hole), five trial pits and two inspection pits. A total of 41 soil samples were taken during the investigation. Six rounds of ground gas and water monitoring have been completed for the monitoring wells installed at the location of the floodlights and for the monitoring wells installed for the new Kop Stand.
- 10.1.3 Made ground was identified at all locations across the site to a maximum depth of 2.80 m bgl generally consisting of gravelly very clayey sand with occasional brick fragments. Underlying the Made Ground was Glaciofluvial sheet deposits with distinct granular and cohesive layers generally consisting of either sandy clayey gravel, slightly gravelly sand or slightly gravelly slightly sandy clay unproven to a maximum depth of 30.42m bgl. Within one location (TP104 from 1.0m bgl) evidence of contamination was observed as a strong hydrocarbon odour.
- 10.1.4 A total of 41 soil samples were taken across the site, analysis results did not record any contaminant concentrations in excess of commercial GAC (which are used as a first screen to determine whether a contaminant is potentially a risk to human health receptors). Asbestos fibres were recorded at one location (IP100 at 0.20m bgl) though when quantified recorded <0.001%.
- 10.1.5 A total of 35 soil samples from across the site were subjected to leachate preparation and testing. Exceedances of EQS screening criteria for metals and PAHs were recorded and the majority from within the Made Ground. Due to the distances to the nearest surface water features and the conservative nature of the screening criteria the leachate exceedances are not thought to represent unacceptable risk. Leachate exceedances of DWS were recorded for benzo(a)pyrene in 13 locations and aromatic (C21-C35) at TP104 at 1.50m bgl. However, these exceedances do not represent a risk as (with the exception of BH100 located in the far north-west) no concentrations of TPH or benzo(a)pyrene were detected within groundwater samples.
- 10.1.6 Within the groundwater samples no exceedances were recorded of DWS. Marginal exceedances were recorded of the EQS for metals, PAHs and chloroform. The exceedances of metals and PAHs are marginal (in the same order of magnitude) and not widespread and thought to present naturally occurring conditions. Chloroform was detected exceeding the EQS screening criteria within BH104, BH105 and BH106, however as there is no identified source on-site this is assumed to be from an off-site source, potentially the former garage to the south of the site.
- 10.1.7 The results of the ground gas assessment show that the site should be classified as 'CS1' (very low hazard) in accordance with BS8485. The results are consistent with the ground conditions encountered, which did not encounter a significant source of elevated ground gases.
- 10.1.8 The site is located within an area where 3-5% of dwellings exceed the radon action level.
- 10.1.9 In conclusion, significant or widespread ground contamination was not found by the GQRA. Some leachable contaminants in exceedance of the relevant GAC typical of urban contaminants were found in the made ground such as metals and polycyclic aromatic hydrocarbons. However, the concentrations detected were relatively modest and common to many brownfield site redevelopments (noting that none were detected above commercial GACs).
- 10.1.10 Development works (the new Kop Stand and four floodlights) will need to consider, for example, risks to construction workers and managing contaminated soils. The contaminants detected are well known and standard health and safety precautions, management plans and waste classification will be required.

10.1.11 Based on Ramboll's initial assessment, ground gas protection is not likely to be required in new buildings.

10.1.12 Further assessment or remediation of groundwater is not considered necessary as a significant risk of pollution was not identified.

10.2 Sustainability

10.2.1 The findings discussed within this report support sustainable development of the site; through strategic sampling and analysis of various environmental media including soil and groundwater, combined with technically robust investigation and risk assessment processes. This facilitates proportionate and scientifically justifiable recommendations to reduce risks to humans and ecosystems alike. It allows for development of sustainable remedial measures and management of soils.

10.3 Recommendations

10.3.1 The assessments undertaken herein have resulted in the identification of a number of plausible pollutant linkages that will require limited mitigation measures to be implemented in order to deliver a site that is suitable for use for the proposed development.

Human Health

10.3.2 Due to elevated concentrations of carbon dioxide within the shallow monitoring wells installed within the Made Ground the contractor should ensure the gas is monitored and have appropriate health and safety measures implemented when undertaking any work in confined spaces within the ground (i.e. during excavations).

10.3.3 Due to the site being located within an area where 3-5% of dwellings exceed the radon action level, the proposed development will require the installation of basic radon protection measures, in accordance with BR 211 for new buildings and GG 75 for new large buildings. As a minimum this will require the incorporation of a damp proof membrane in the floor, linked to a damp-proof course within the walls of the building. Joints in the membrane and any service penetrations through the membrane will need to be properly sealed.

Materials Management

10.3.4 The material in the vicinity of TP104 is suitable to remain in-situ however care should be taken not to bring the material to the surface. If excavated and not reused elsewhere at the site (under an MMP, exemption from the Environmental Permitting Regulations or similar) the material would need to be disposed off-site as hazardous waste, although other options could include recycling the material at another site (with due regard to the Environmental Permitting Regulations).

Site Controls During Construction

10.3.5 Standard best practice and mitigation measures should be implemented during the construction works to minimise the potential risks to the environment. These are listed in Appendix 5.

Unexpected contamination

10.3.6 In accordance with good practice in developing brownfield land, it is recommended that the unexpected contamination protocol presented in Appendix 6 is implemented during ground works to watch for any unforeseen ground conditions or localised contamination hotspots (i.e. concentrated pockets of ash, asbestos or hydrocarbons). If previously unforeseen contamination is identified, the risk assessment provided in this report may need to be updated.

Verification Plan

10.3.7 It will be necessary to provide verification to demonstrate that the required mitigation measures have been implemented, so that a Verification Report can be prepared on completion of the construction works. A list of information that should be recorded / collected by the Contractor during the construction works is listed in Appendix 7.

Long Term Monitoring Requirements

10.3.8 No requirement has been identified for long term groundwater monitoring as part of the works.

Post-Construction Constraints

10.3.9 On the basis that any mitigation requirements identified will be implemented at the construction stage, no specific constraints have been identified relating to land quality with the potential to impact activities following the construction works.

If unexpected contamination is identified during the construction works, the post-construction constraints may need to be updated.

10.4 Discharge of Planning Conditions

10.4.1 It is recommended that this report is submitted alongside the Geotechnical and Contaminated Land Desk Study Report to the Local Planning Authority and its consultees to support the discharge of Planning Condition No. 6 (Risk of contamination) I, II & III, prior to commencement of construction works at the site. The information included within this report regarding the management of contaminated land (Section 10.3 alongside Appendices 6, 7 & 8) will also support the discharge of Planning Condition No. 6 IV by fulfilling the requirement of a remediation strategy and a verification plan. Section 10.3.6 and Appendix 6 sets out the framework under which planning condition No. 9 (Contamination remediation strategy) would be discharged in the event that unexpected contamination is encountered. A remediation options appraisal (noted under Planning Condition 6 III) is not considered to be necessary given the low level of risk that has been identified at the site.

10.4.2 The verification report required by Planning Condition No. 7 (Verification report) will need to be prepared in due course on completion of the earthworks for the project, but due to the nature of the report, this cannot be prepared prior to commencement.

10.4.3 It is considered that a long term monitoring plan for land contamination (as described under planning condition No. 8) will not be required for the proposed development. This is on the basis that limited contamination has been identified at the site and the risks to human health and controlled waters is considered to be low. No remediation works are deemed necessary, therefore the need for longer term monitoring is not warranted.

10.4.4 The Foundation Risk Assessment included in Section 8 of this report is considered to be sufficient to discharge the requirements under Planning Condition No. 10 (Details of piling). It is acknowledged that the pile design for the floodlights has not been confirmed at this stage, but should the final pile design differ significantly from the assumptions made in this report the Foundation Risk Assessment will be updated and resubmitted to the LPA for approval.

10.4.5 It is recommended that Planning Condition No. 11 (Infiltration permission) is discharged on the basis that the contaminated land qualitative risk assessment has concluded that the risk to controlled waters (groundwater in the underlying Secondary A aquifer in the Glaciofluvial Sheet Deposits and Sandstone bedrock) is very low, due to the limited contamination present within made ground and the limited evidence of any existing contamination impact in groundwater beneath the site. As such, an infiltration led drainage strategy is proposed and the design is being progressed on that basis.

FIGURES

FIGURE 1 Site Location

FIGURE 2 Site Investigation Locations

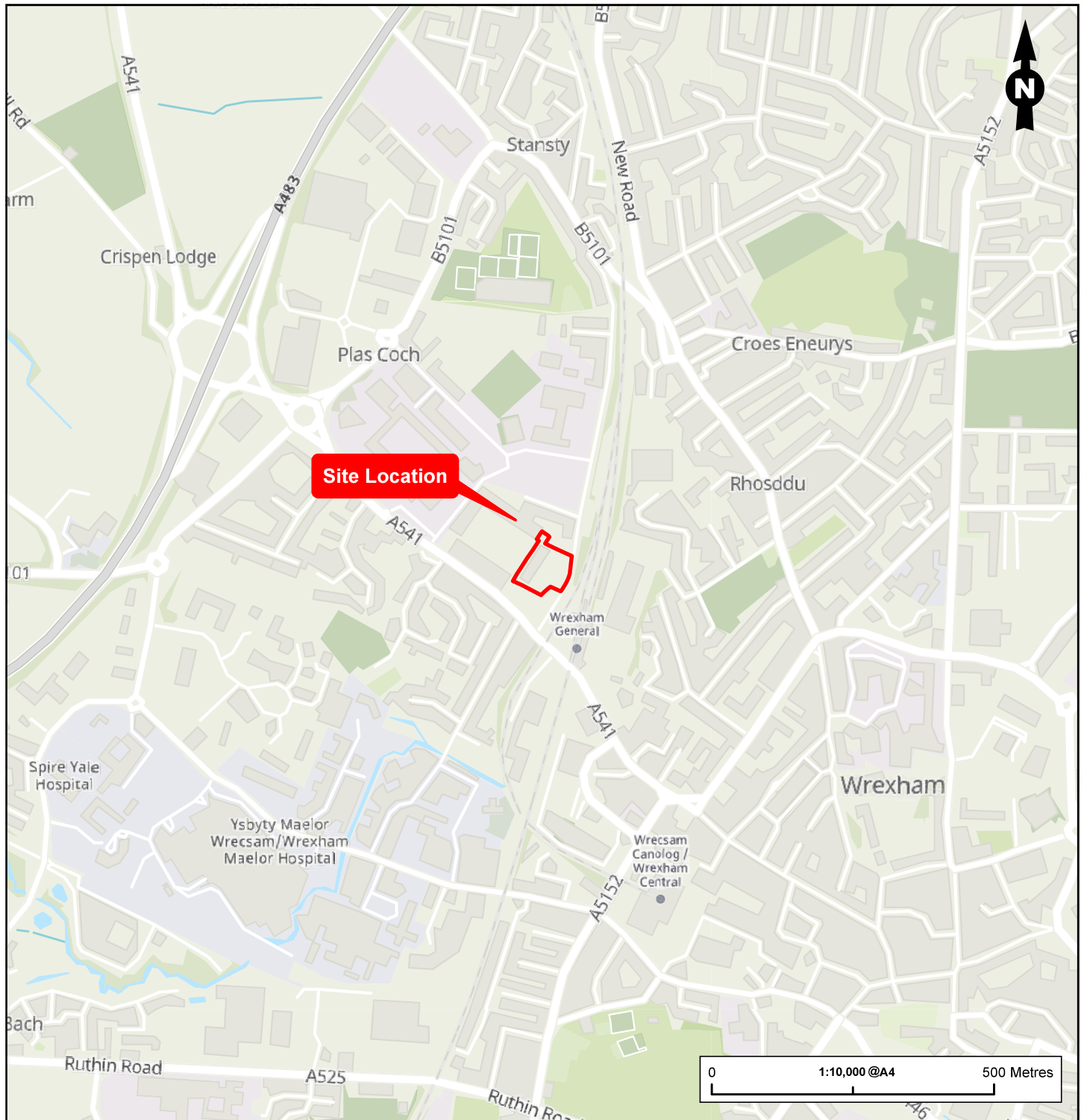
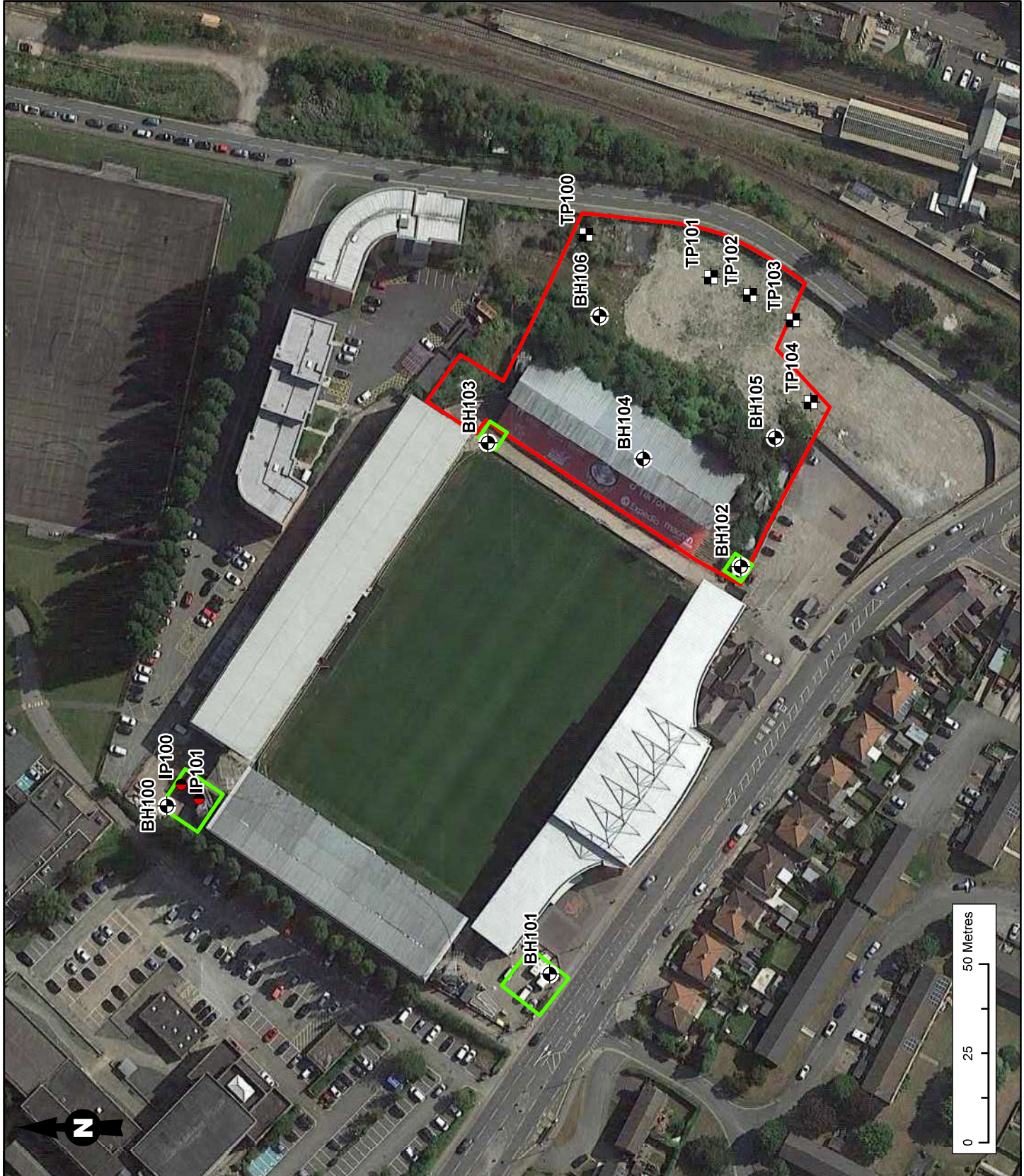


Figure Title Figure 1: Site Location	Project Name New Kop Stand and Floodlights	Date April 2023 Scale As shown	
Project Number 1620012485	Client Wrexham Association Football Club	Issue 1 Prepared By CT	



Legend		Figure Title	
	Borehole	Exploratory Hole Plan	
	Inspection Pit	Project Name	
	Trail Pit	New Kop Stand and Floodlights	
	New Kop Stand Boundary	Project Number	Figure No.
	New Floodlights	1620012485	2
		Date	Prepared By
		April 2023	CT
		Scale	Issue
		1:1,500 @A4	2
		Client	
		Wrexham Association Football Club	

DRAWINGS

MLD-EX-XX-DR-L-1003 P02

Site Plan – Option 3

WRX-RAM-04-FN-DR-S-10091 P03

Level FN Foundation Plan General Arrangement Sheet 1

PURPOSE OF ISSUE

DRAWN BY Author	CHECKED BY Checker	DATE 10/11/22
SCALE (@ A1) 1 : 200		PROJECT NUMBER 22202
DRAWING NUMBER		

