Hydrock

Bicester Motion Innovation Centre

Desk Study Review & Ground Investigation Report

For Bicester Motion

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Executive summary

Site information and setting	
Objectives	The works have been commissioned to assist in clearing planning conditions and to assist with the design of the development.
Client	Bicester Motion.
Site name and location	Bicester Motion Innovation Centre. Located in the southeast of the wider Bicester Motion Site at a nearest postcode of OX26 5AF.
Proposed development	The site development proposals are understood to comprise commercial / industrial units along the boundary with Skimmighdish Lane along with associated car parking and roadways
Site description	The site covers an area of approximately 10.3ha and is a generally flat area of open land, with some local undulations and a number of vegetation-covered mounds. There is an asphalt/tarmac covered car park in the far northwest corner of thew site, and a short section of asphalt/tarmac covered road in the east.
Desk study summary	
Hydrology	The nearest surface water feature is a Audley Brook approximately 150m to the north-west of the site, which drains into Langford Brook approximately 550m to the east.
Site History	The site was predominantly agricultural land from 1881 until 1920 when the wider site was operated as RAF Bicester. After the war it was used for storage, maintenance, repair and salvage of aircraft and equipment until 1976, when it ceased being an active station. The United States Air Force used the site between 1978 until 1994, then it was used again used by the RAF until 2004. The current site area uses include a former rifle range, former 'old dump' and pillboxes and seagull trenches present which remain to this day with the site generally overgrown prior to the site works.
Geology	Superficial: None recorded Solid: Cornbrash Limestone Formation over Forest Marble Formation
Hydrogeology	The Cornbrash Limestone Formation and Forest Marble Formation are classed by the Environment Agency as Secondary A Aquifers. The site is not within a Groundwater Source Protection Zone.
Radon	The site is not in a radon affected area (1-3%) of homes above the action level.
UXO risk	A specialist UXO assessment indicates a moderate UXO risk.
Preliminary conceptual site model based on desk study	
Potential contaminant sources	Made Ground associated with historical construction activities / fill. Made Ground in the former landfill / 'old dump' area. Cal tar in bituminous bound pavements. Asbestos from old buildings.
Potential contaminant linkages (for receptors for which there is or will be a pathway)	People (site users, neighbours). Groundwater: Secondary A aquifer status of the River Terrace Deposits. Surface water: on-site drainage ditch and ponds 450m to the south. Development end use (buildings, utilities and landscaping).

Ground model proven by investigation	
Ground and groundwater conditions encountered by investigation	The ground conditions as proven by the investigation(s) including re-interpretation of historical reports by Hydrock, comprise: • Made Ground Topsoil – was encountered from surface to between 0.10m bgl to 0.70m bgl. comprising soft slightly sandy, slightly gravelly clay, with frequent roots and rootlets and occasional to rare fragments of brick, glass, ash, slag, asphalt and coal or slightly gravelly, locally clayey, locally sandy and locally slightly peaty silt, with rare to occasional brick, 'ballast' and 'macadam' fragments • Made Ground – Landfill to between 0.25m bgl and 2.20m bgl within the centre of the site comprising variable strata (predominantly gravel) with fragments of macadam, clinker, brick, glass ironstone and ash. • Made Ground – Locally beneath the Made Ground Topsoil to depths of between 0.10 or from surface in gravel surfaced areas comprising various strata comprising cobbles and boulders of limestone, sandy slightly clayey gravel and brick rubble with silt and clay. • Cornbrash Limestone Formation underlying the Made Ground in all locations except TP103 to between >0.60m bgl to 3.60m bgl comprising a light brown/yellowish brown very thinly bedded ooidal shelly limestone recovered as a clayey to silty fine to coarse gravel with some cobbles and boulders • Forest Marble Formation encountered in TP103, BH01 & WS04 only underlying the Cornbrash Limestone Formation (Cornbrash) or Made Ground – Landfill (TP103) comprising interbedded stiff grey clay and where less weathered strong bluish grey limestone. Shallow groundwater was encountered in the Cornbrash, although many of the shallowest holes did not encounter groundwater at all during excavation Water levels post-fieldwork from both investigations indicate a shallow groundwater table generally at between approximately 0.50m and 1.50m bgl. There was no visual and olfactory evidence of contamination within water during investigations.
Summary of geotechnical conclusions	
Groundwork	Whilst no buried obstructions were encountered by this investigation, the possibility of buried obstructions being encountered remains and limestone has been encountered at shallow depth. Following breaking out of hardstanding and obstructions, excavation of shallow soils should be readily undertaken by conventional plant and equipment. However, excavation through any intact rock quality strata may require heavy-duty excavation plant/ripping plant the use of specialist breaking equipment. Trial pit faces were noted to remain generally vertical without collapse Water seepages into excavations are likely to be adequately controlled by sump pumping
Foundations	Foundations are recommended to comprise pad foundations with 110kpa load within the weathered Cornbrash and 250kPa on the deeper rock quality stratum. Deepening of foundations/heave protection may be required to allow for the effects of trees (where clay is present at shallow depth). On the basis that excavation and replacement of the softer soils will be undertaken and all structural fill will be placed strictly in accordance with an appropriate Earthworks Specification, then ground bearing floor slabs may be adopted with an allowable bearing pressure of 50kN/m^2.
Roads and pavements	For road / pavement design, a design CBR of 3 % is recommended.
Sustainable drainage	Groundwater levels are generally shallow within the Cornbrash. As such soakaways are not considered suitable across the site due to limited available storage capacity and risk of mobilising contaminants (within some areas of the site),. . Shallow infiltration will only be viable where Made Ground is not present.
Buried concrete	Design Sulfate Class - DS-1 and ACEC Class AC-1. Equivalent to Design Chemical Class DC-1 for a 50 year design life.

Summary of geo-environmental assessment	
Human Health	• PAH in the Made Ground – Topsoil and Made Ground – Landfill • Asbestos within the Made Ground – Topsoil and Made Ground – Landfill • Lead in the Made Ground – Landfill • Coal Tar in sample A1 indicated.
Phytotoxicity	Zinc and copper in the Made Ground – Topsoil and Made Ground - Landfill
Controlled waters	Considered to be a low risk based on historical assessment.
Radon:	The site is in not in a Radon Affected Area (1 to 3%) of existing homes affected).
Potable water supply pipes	Exceedances in Made Ground above the threshold values are noted in some soil at depths <0.50m bgl. Subject to agreement with the local water supply company, it may be possible for the site to be classified as non-contaminated, from the perspective of the water supply pipe requirements, with standard pipework for pipes within natural soils at the site. Alternatively, it may be necessary to prepare separate water pipe risk assessments on a plot-by-plot basis in order to demonstrate to the water supply company the suitability of standard polyethylene pipework
Ground gases or vapours:	Low risk from ground gases and CS1 conditions apply.
Enabling works	
Proposed mitigation measures	The mitigation measures proposed to remove unacceptable risks include: • break out of all hardstanding and below ground obstructions and processing for reuse in accordance with a suitable specification and a Materials Management Plan (MMP) (PL4). • import of subsoil and topsoil in accordance with the Materials Management Plan (MMP) (PL1 - 3); • The installation of a 300mm engineered cover system in soft landscaped areas (where required) comprising a bonded geogrid break layer (e.g. TX160G), subsoil beneath a topsoil thickness of between at least 100mm and 300mm (PL1 - PL3). with deepening of the cover system where required to account for trees and shrub planting. • Installation of Protectaline pipework if required (PL5). The methodology for the remediation should be presented in a Remediation Strategy, which will need to be submitted to the warranty provider and the regulatory authorities for approval. Verification reports by a competent independent geo-environmental specialist will be required following completion of any remedial works.
Earthworks	In order to undertake the proposed cut to fill earthworks and use of excavated materials in earthworks a site specific Earthwork Specification will be required to allow reuse of suitable materials along with the production of a Materials Management Plan and its approval by a Qualified Person. Verification reports by competent independent geotechnical specialists will be required following completion of any earthworks.
Waste management	Excavated Made Ground – Topsoil, Made Ground are likely classified as non-hazardous. Made Ground – Landfill is likely to be classified as hazardous. natural uncontaminated subsoils are likely to be classified as 'inert' waste and should be able to be disposed of at an inert landfill. Any soils containing > 0.1% asbestos or visible asbestos containing materials would be considered as hazardous. General Made Ground, topsoil and natural soils can be reused on site (as deemed appropriate by the Remediation Strategy. However, the Landfill Made Ground is currently a waste, and as such, can not be re-used on site (without extensive and long-term discussions with the Environment Agency. Any excavated Landfill Made Ground is to be disposed of off-site

Future considerations	
Further work	Following the ground investigation works undertaken to date, the following further works will be required: • discussion and agreement with utility providers regarding the materials suitable for pipework; • discussions with regulatory bodies and the warranty provider regarding the conclusions of this report; • assessment of tree influence on foundations and design of foundations; • provision of geotechnical design for the Category 2 (earthworks, floor slabs, foundations etc.); • production of a Remediation Strategy and Verification Plan (and agreement with the regulatory bodies and the warranty provider); • production of a Materials Management Plan relating to reuse of soils at the site and import of soils to the site; • remediation and mitigation works; and • verification of the earthworks, remediation and mitigation works.

This Executive Summary forms part of Hydrock Consultants Limited report number 27280-HYD-XX-XX-RP-GE-1001-S2-P02 and should not be used as a separate document.

1. Introduction

1.1 Terms of reference

In July 2023, Hydrock Consultants Limited (Hydrock) was commissioned by Bicester Motion (the Client) to undertake site investigation, comprising a Desk Study review and Phase 2 supplementary ground investigation in the south-east of the proposed wider Bicester Motion site at a nearest postcode of OX26 5AF.

The site was until recently overgrown with vegetation and is currently disused.

Hydrock understands that the proposed development is to comprise warehouse units along the boundary with Skimmighdish Lane along with associated car parking and roadways. A proposed site plan for Phase 2 (Drawing 220127-3DR-ZZ-00-DR-A-07008), is presented in Appendix A.

The investigation works have been undertaken in accordance with Hydrock's proposal reference 27280-HYD-XX-ZZ-FP-GE-0001-P2 dated 4th April 2023 and the Client's instructions to proceed (PO BM01090).

1.2 Objectives

The works have been commissioned to assist in clearing planning condition 18 of outline planning permission 19/02708/OUT and to assist with the design of the development.

The objectives of the Phase 1 Desk Study review are to formulate a preliminary Ground Model and an Initial Conceptual Site Model of the site to identify and make a preliminary assessment of any potential geo-environmental and geotechnical risks to the proposed development.

The objectives of the Phase 2 Ground Investigation are:

- To provide a detailed Ground Model of the site (including modelled surfaces of the base of Made Ground and Cornbrash) and groundwater levels
- to identify any geo-environmental mitigation requirements to enable development to progress; and
- to provide preliminary geotechnical recommendations for design.

1.3 Scope

The site investigation includes a Phase 1 Desk Study and a Phase 2 Ground Investigation.

The scope of the Phase 1 Desk Study comprises:

- a field reconnaissance (walkover) to determine the nature of the site and its surroundings including current and former land uses, topography and hydrology;
- a review of:
  - historical Ordnance Survey maps, to identify any; former potentially contaminative uses shown at the site and immediately surrounding it, and an assessment of the associated contamination risks;
  - third-party environmental report to identify any; flooding warning areas, local landfills, pollution incidents, abstractions, environmental permits etc. All of which may have had the potential to have environmental impact on the site;
  - topographical, geological and hydrogeological maps;
  - British Geological Survey (BGS) archive records;
  - regional UXB risk maps;
  - a site-specific specialist UXO Desk Top Study

- a review of previous investigations carried out at the site;
- development of a preliminary Ground Model representing ground conditions at the site;
- development of an initial Conceptual Site Model (iCSM), including identification of potential contaminant linkages;
- a qualitative assessment of any geo-environmental risks identified; and
- identification of any plausible geotechnical hazards.

The scope of the Phase 2 Ground Investigation comprises:

- a supplementary ground investigation including trial pitting and windowless sampling under UXO supervision to:
  - obtain data on the ground and groundwater conditions of the site;
  - allow collection of samples for geotechnical and chemical laboratory analysis;
  - allow geotechnical field tests to be undertaken;
  - install gas and groundwater wells;
- gas concentration and groundwater level monitoring;
- geotechnical and chemical laboratory analysis;
- updating of the preliminary Ground Model;
- preparation of a geotechnical risk register;
- presentation of an initial geotechnical design recommendations;
- formulation of an updated Conceptual Site Model (CSM), including identification of any plausible contaminant linkages;
- completion of a generic quantitative risk assessment of any identified chemical contaminants to establish 'suitability for use' under the current planning regime;
- discussion of any potential environmental liabilities associated with land contamination (soil, water and gas); and
- identification of outline mitigation requirements to ensure the site is 'suitable for use'.

1.4 Available information

The following documents, reports etc have been provided to Hydrock by Bicester Motion for use in the preparation of this report:

- Carl Bro Group Limited. January 2003. Phase 2 Land Quality Assessment – RAF Bicester, Ref: 73.1247.02.
- Carl Bro Group Limited. January 2003. Phase 2 Land Quality Assessment – RAF Bicester Technical Note, Ref: 73.1247.02.
- Carl Bro Group Limited. February 2003. Phase 2 Land Quality Assessment – RAF Bicester ESA, Ref: 73.1247.03.
- Carl Bro Group Limited. February 2003. Phase 2 Land Quality Assessment – RAF Bicester ESA Technical Note, Ref: 73.1247.03.
- Grontmij Group Limited. April 2008. Phase 2 Land Quality Assessment - Update – RAF Bicester Ref: P0000462400.
- Grontmij Group Limited. June 2008. Phase 2 Land Quality Assessment – RAF Bicester - Technical Note, Ref: P0000462400.
- Crestwood Environmental Limited. July 2018. Phase 1 Land Contamination and Ground Condition Report, Ref: CE-BE-1363-RP03-Draftv1.0.

- Geo-Integrity. October 2018. Phase 1 and Phase 2 Report – New Technical Site – Bicester Heritage, Ref: 18-08-08.
- Ridge and Partners LLP. November 2019. Bicester Motion – F.A.S.T HUB. Flood Risk and Drainage Assessment. Ref: 5002854-RDG-XX-ST-DOC-C-0052.
- Cherwell District Council. November 2019. Outline Planning Determination. Bicester Heritage, Buckingham Road, Bicester. Ref: 19/02708/OUT.
- Ridge and Partners LLP. December 2020. Review of Ground Investigation Reports & Detailed UXO Desk Study. Bicester Motion – Innovation Quarter. Ref 5012836-RDG-XX-ST-DOC-C-00LR01.Ridge and Partners LLP.
- Ridge and Partners LLP. June 2021. Ground Condition Assessment. Bicester Motion – Innovation Quarter. Ref: 5015203-RDG-XX-ST-DOC-C-00GCA01.

It is understood that the Client defined in Section 1.1 commissioned / has obtained assignment of the above documents and Hydrock has assumed full reliance can be placed upon their contents. Should this not be the case, Hydrock should be informed at the earliest opportunity.

A desk study (Geo-Integrity 2018) provided by Bicester Motion is included in Appendix C and the content is summarised in Section 2 . This content has been used in the preparation of the preliminary Conceptual Site Model as the basis for preparing the preliminary geo-environmental exposure model and the preliminary geotechnical hazard identification presented in Section 3

1.5 Regulatory context and guidance

The investigation work has been carried out in general compliance with recognised best practice, including (but not limited to) BS 5930:2015+A1:2020, BS 10175:2011+A2:2017 and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

The geo-environmental section of this report is written in broad accordance with BS 10175:2011+ A2:2017, EA LCRM (2023) and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

The methods used follow a risk-based approach, the first stage of which is a Phase 1 desk study review and field reconnaissance, with any potential geo-environmental risks assessed qualitatively. This is done using the 'source-pathway-receptor contaminant linkage' concept to assess risk as introduced in the Environmental Protection Act 1990 (EPA, 1990). Any potential geotechnical risks are also assessed from the Phase 1 desk study and site reconnaissance stage.

Phase 2 comprises intrusive ground investigation work and testing. The factual information from the desk study and the ground investigation are used to develop the Conceptual Site Model (CSM). This CSM is based on a ground model of the site physical conditions and an exposure model of the possible contaminant linkages. The CSM forms the basis for Generic Quantitative Risk Assessment (GQRA) in accordance with current guidelines. This GQRA might lead to more Detailed Quantitative Risk Assessment (DQRA).

Professional judgement is then used to evaluate the findings of the risk assessments and to provide recommendations for the development.

The geotechnical section of this report is prepared in general accordance with BS EN 1997-1+A1: 2013, BS EN 1997-2:2007 and BS 8004:2015. This report constitutes a Ground Investigation Report (GIR) as described in Part 2 of Eurocode 7 (BS EN 1997-2) (EC7). However, it is not intended to fulfil the requirements of a Geotechnical Design Report (GDR) as specified in EC7.

Where relevant the relevant requirements of the current edition of NHBC Standards have also been applied.

The geo-environmental and geotechnical aspects are discussed in separate sections. Throughout the report the term 'geotechnical' is used to describe aspects relating to the physical nature of the site (such as foundation requirements). The term 'geo-environmental' is used to describe aspects relating to ground-related environmental issues (such as potential contamination). However, it should be appreciated that this is an integrated investigation and these two main aspects are inter-related. Designers should take all aspects of the investigation into account.

Remaining uncertainties and recommendations for further work are listed in Section 9 and Section 10.

2. Desk study review (and field reconnaissance)

2.1 Site referencing

Table 2.1: Site referencing information

Item	Brief Description
Site name	Bicester Motion Innovation Quarter
Site address	Skimmingdish Lane, Bicester. Nearest postcode is OX26 5AF.
Site location and grid reference	The Bicester Motion site is located in the south-east of the wider Bicester Motion Site approximately 1.7km to the northeast of Bicester Town Centre. The National Grid Reference for the approximate site centre is 459624, 223986

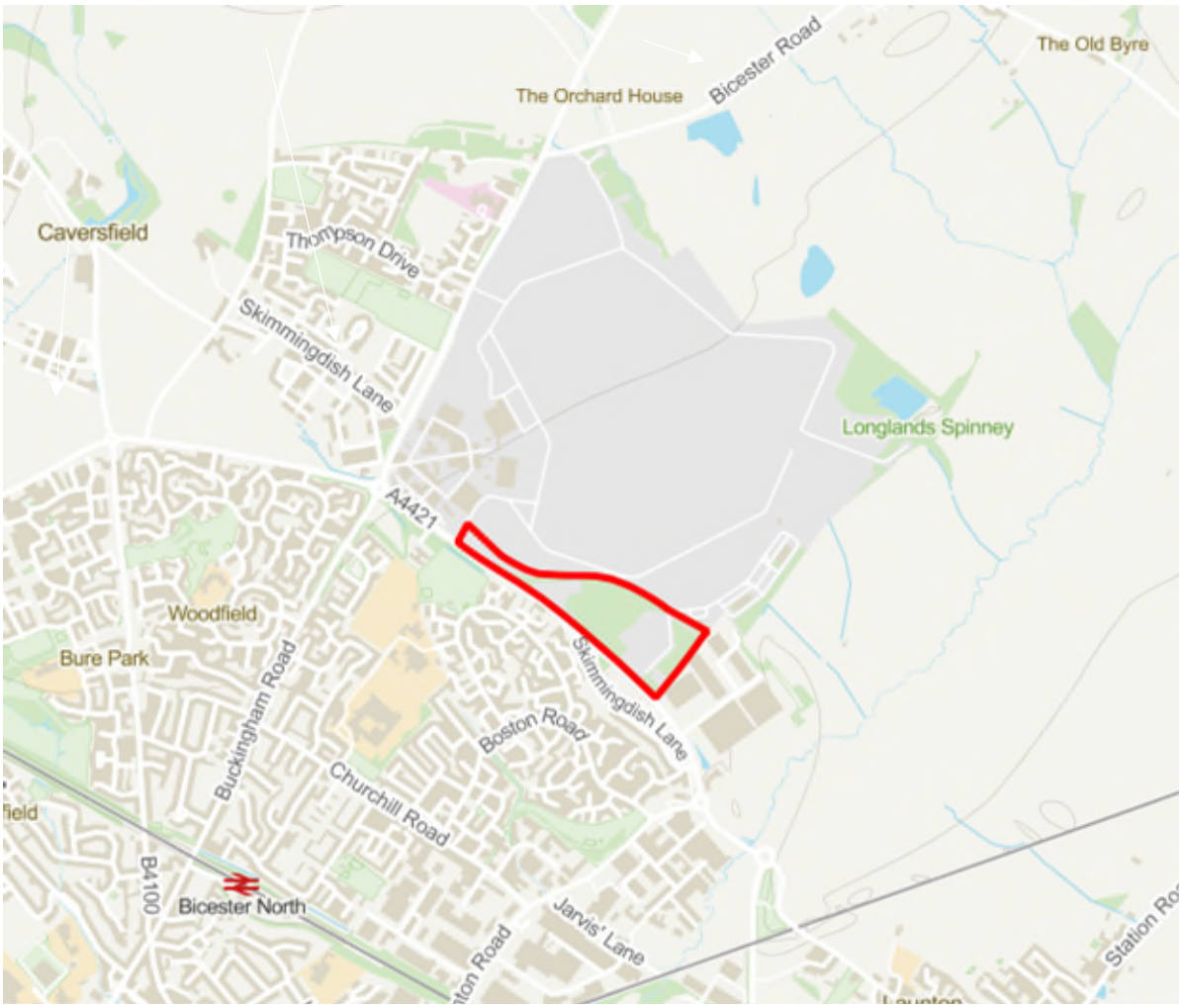

Figure 2.1: Site location

A site location plan (Hydrock Drawing 27280-HYD-XX-ZZ-DR-GE-1001) is presented in Appendix A.

2.2 Historical Reports

As part of the desk study information, a number of previous ground investigations undertaken at the site have been reviewed (see Section 1.4). The reports pertinent to the Innovation Centre site area are summarised in Section 2.2. Where suitable, the data from these reports is included in this report.

The historical works undertaken and a high-level summary of the findings of each report is provided in Sections 2.2.1 to 2.2.7 below.

2.2.1 Carl Bro Group Limited. January 2003. Phase 2 Land Quality Assessment Volume II – RAF Bicester, Ref: 73.1247.02.

These works were undertaken by Carl Bro Group on behalf of Defence Estates and comprise the results of laboratory chemical analysis on soil and water samples.

2.2.2 Carl Bro Group Limited. January 2003. Phase 2 Land Quality Assessment – RAF Bicester Technical Note, Ref: 73.1247.02.

These works were undertaken by Carl Bro Group on behalf of Defence Estates. The site area referenced in this report encompasses the entire former RAF Bicester site of which the proposed Innovation Quarter makes up a portion. As Hydrock has not been provided with the logs from this investigation, the ground conditions outlined in this report cannot be confirmed by Hydrock. In addition, the laboratory results referenced in both Carl Bro reports (Section 2.2.1 and Section 2.2.2) are 20 years old. No reliance can be placed on the laboratory results as both testing and assessment criteria has been updated significantly since these results were reported.

The report comprises:

- a review of site history;
- assessment of the environmental setting;
- a qualitative environmental risk assessment;
- a liability assessment of historical contamination issues at the site in relation to relevant environmental legislation;
- a management study summarising the potential management alternatives for dealing with land quality issues;
- financial risk analysis in relation to the management study; and
- overall land quality and suitability for redevelopment assessment.

The report noted:

- The wider site was occupied by the Royal Flying Corps in 1920, the RAF from 1928 to 1976 (when it ceased being an active station) and the USAF took over the technical site from 1978 to 1994. It was used as a logistical centre and training centre (1939-1945) and a transit centre and aircraft repair and salvage station (1945-1976). Since 1994 the site has been used by a gliding club.
- On site sources of potential contamination include; UXO in the old dump, asbestos in soils, metals, hydrocarbons. The Stratton Audley landfill site was also identified as a potential off-site source of contamination.
- Two locations within the old dump area recorded radiological readings that were slightly elevated when compared to background levels. Gas spectroscopy analysis confirmed that the elevated readings were not high enough to be deemed radioactive.

- Four pieces of ordnance were identified in the old dump area, two during a visual inspection prior to investigations and two in a trial pit during investigations.
- Intrusive investigations (5 boreholes [maximum 5m below ground level (bgl)] and 25 trial pits [maximum 3m bgl]) identified Made Ground to depths of 1.30m bgl to 2.20m bgl. Olfactory evidence of contamination within this material was recorded including; ash, coal, metal and black organic odorous matter was encountered during investigations.

The report concluded:

- Asbestos containing materials were present in two soil samples collected from the old dump area.
- The risk of UXO was considered as high due to the potential presence of further UXO being present in this area.
- There were elevated concentrations of hydrocarbons (PAH's, Xylene and TPH) and metals (As, B, Cu, Ni and Zn) in both soil and groundwater samples in the old dump area.
- The potential risk to groundwater was considered to be moderate to low. The uppermost aquifer was considered to represent an unviable resource due to its limited extent. In addition, the report concluded that the clay layer above the lowermost aquifer would inhibit downward migration of contaminants into this aquifer.

2.2.3 Grontmij Group Limited. April 2008. Phase 2 Land Quality Assessment - Update – RAF Bicester Ref: P0000462400.

Grontmij Group Limited (formerly Carl Bro) was commissioned by Defence Estates to write an updated Phase 2 LQA, based on the original Phase 2 LQA completed by Carl Bro Group Limited in 2003. The site area referenced in this report encompasses the entire former RAF Bicester site of which the proposed Innovation Quarter makes up a portion. Grontmij conducted further investigations across the former RAF Bicester site but not in the old dump and rifle range as it was considered that there was sufficient data in these areas from the 2003 investigation. As mentioned in section 2.2, as this report is based on laboratory data and logs from the 2003 Carl Bro report, Hydrock cannot place reliance on chemical testing results or ground conditions.

The report comprised;

- an updated site history from the previous report;
- an updated assessment of the environmental setting;
- an updated potential contaminative site uses from the previous report;
- supplementary site investigation data and interpretation around the wider site area (excluding the old dump and rifle range area);
- chemical analysis results; and
- an updated environmental risk assessment from the previous report.

The report noted:

- The old dump site remains overgrown with dense vegetation and disused, with exploratory hole locations mostly inaccessible.
- The remaining risk of UXO in the old dump site.
- With regard to soil concentrations:
- Soil concentrations exceeding generic screening values (GSV) for residential with plant uptake end use in the old dump site; metals (As, Cd, Cu, Ni, Pb, Zn), asbestos (chrysotile) and PAH (Benzo[a]pyrene, Dibenz(ah)anthracene).

- Soil concentrations exceeding generic screening values (GSV) for industrial/commercial end use in the old dump site; metals (Pb), asbestos (chrysotile) and PAH (Benzo[a]pyrene).
- With regard to groundwater/leachate concentrations:
- Groundwater concentrations exceeding GSV in the old dump site; PAH (Benzo[a]pyrene, anthracene, fluoranthene).
- Leachate concentrations exceeding GSV in the old dump site; metals (Pb and Ni).

The report concluded:

- With regard to the old dump area:
  - The risk to future industrial/commercial site users as moderate/low within the Old Dump area assuming localised remediation of TPH, PAH, asbestos and lead impacted soils exceeding soil screening criteria.
  - The risk of radioactive contamination to be present across the old dump area remains low.
- With regard to the wider site area:
  - Assuming that localised remediation of TPH and PAH impacted soils will take place in, the risk to surface/groundwater is assessed as moderate/low.
  - The risk to fauna and vegetation under current site use is negligible. Contamination in relation to plant uptake may be possible in future use redevelopment, in this case the risk is assessed as low.
  - Assuming that there is no change to property (building/structures) the risk is assessed as low.

2.2.4 Grontmij Group Limited. June 2008. Phase 2 Land Quality Assessment – RAF Bicester -Technical Note, Ref: P0000462400.

Grontmij Group Limited (formerly Carl Bro) was commissioned by Defence Estates to write an updated Phase 2 LQA Technical Note, based on the original Phase 2 LQA Technical Note completed by Carl Bro Group Limited in 2003. The site area referenced in this report encompasses the entire former RAF Bicester site of which the proposed Innovation Quarter makes up a portion. The purpose of the report is to provide updated management and remedial options for the site. As mentioned in section 2.2, as this report is based on laboratory data and logs from the 2003 Carl Bro report, Hydrock cannot place reliance on chemical testing results or ground conditions.

The report comprises:

- a review of site history;
- assessment of the environmental setting;
- a qualitative environmental risk assessment;
- a liability assessment based on contamination identified during the 2003 investigation in relation to relevant environmental legislation;
- a management study summarising the potential management alternatives for dealing with land quality issues;
- financial risk analysis in relation to the management study; and
- overall land quality and suitability for redevelopment assessment.

Elevated concentrations of lead, arsenic, chromium, nickel and cadmium above industrial screening levels and some localised PAH contamination are reported in the soils in “the old dump” (backfilled quarry) area.

The remedial options for LQA issues for an industrial end use include:

- Remediation of localised contamination and capping area in the old dump area. Remediation works should be based on the findings of further investigation of the site and tier 2 targets generated by a QRA to be protective of human health.
- Bioremediation: A volume of approximately 3200m^3 is likely to require excavation to remove human health risks. On site bioremediation would enable re-use of this material.
- Capping of localised lead contamination – using site won material: An area of 17,000m^3 has been estimated to require capping with a 1m thick clean cover to remove the pathway for human health risks to controlled water through leaching. This would also require validation.
- Capping of localised lead contamination – using imported material: An area of 17,000m^3 has been estimated to require capping with suitable import material which will require validation.

2.2.5 *Crestwood Environmental Limited. July 2018. Phase 1 Land Contamination and Ground Condition Report, Ref: CE-BE-1363-RP03-Draft v1.0.*

Crestwood Environmental Limited was commissioned by Bicester Heritage Centre to undertake a Phase 1 Land Contamination report to assess the potential of land contamination and ground condition impacts for a proposed Mixed Use Development on the wider Bicester Motion site, of which the Innovation Centre site is the southern corner.

The report provides a site history (reproduced in Section 2.4) and site setting (used to inform the site description, geology, hydrogeology and hydrology sections of this report (sections 2.3 and 2.5 to 2.8), as well as a preliminary risk assessment, outlined below.

The following potential contamination sources (potential contaminants in brackets) relevant to the Innovation Centre site are identified:

- Wastes in the former quarry (see below) (asbestos, BTEX, PAH, TPH and metals).
- Fuel, oil and solvent storage/use (BTEX, PAH, TPH and metals[1] (*sic*)).
- a Category 3 'Minor' pollution incident (diesel spill) in September 2002 at the former quarry area.

The following potential receptors are identified:

- Construction workers, during development.
- Future site users.
- Ecological systems.
- Groundwater.
- Surface water in the vicinity of the site.
- New buildings.

The conceptual site model identifies the following risks as being moderate-low:

- Inhalation and/or ingestion of, or direct contact with contaminants in soil (not including asbestos).
- Inhalation of asbestos fibres during development or future use.
- Migration of contamination to the groundwater.

[1] It is considered that reference to metals is a typo in the Crestwood report due to copying the list of wastes from the quarry, as metals would not be considered a potential contaminant from fuel, oil or solvent storage and use..

- Migration of contaminated groundwater to surface waters.

All other potential source-pathway-receptor contaminant linkages were recorded as low risk.

Whilst not a geo-environmental risk, the risks to development workers and site users from unexploded Ordnance (UXO) was also identified as moderate-low.

The report notes that there is a geological Site of Special Scientific Interest (SSSI), the Stratton Audley Quarries, part of which is the former quarry in the approximate centre of the Innovation Centre site. However, according to the quoted Natural England citation, due it being "largely infilled with waste material...even if an exposure had been retained along the south or eastern edges of the pit, it is completely inaccessible and there is no visible exposure". The citation apparently states there are no practical means of restoring access to the interest feature and therefore the SSSI must be assessed as 'destroyed'.

2.2.6 *Ridge and Partners LLP. December 2020. Review of Ground Investigation Reports & Detailed UXO Desk Study. Bicester Motion – Innovation Quarter. Ref 5012836-RDG-XX-ST-DOC-C-00LR01.Ridge and Partners LLP.*

This report comprises a review of the historical data pertinent to the Innovation Centre site in the reports summarised above, and a desk based UXO risk assessment report. It concludes that a supplementary ground investigation is needed to determine ground conditions to assist in the design of the proposed buildings and associated infrastructure and to further refine the geo-environmental constraints to the proposed development.

It notes that a more detailed and less conservative quantitative risk assessment should demonstrate that most of the identified S-P-R linkages do not pose a significant risk to human health or controlled waters.

It also recommends specific measures to be followed when planning and carrying out the ground investigation to minimise the risk from UXO.

Finally, it outlines a proposed scope of work for the ground investigation, which is what was subsequently undertaken (see below).

2.2.7 *Ridge and Partners LLP. June 2021. Ground Condition Assessment. Bicester Motion – Innovation Quarter. Ref: 5015203-RDG-XX-ST-DOC-C-00GCA01.*

This report comprises a review of the historical data in the reports summarised above, together with assessment of the results of an intrusive investigation comprising:

- Four rotary boreholes (maximum depth of 10m).
- Ten trial pits.
- Six soil infiltration rate tests.
- Fifteen windowless sample boreholes
- Eleven TRL DCP tests.
- Laboratory geotechnical testing and contamination analysis.
- Six rounds of ground gas and groundwater monitoring.

Ground conditions encountered are summarised as:

- Made Ground to a maximum depth of 1.20m bgl.
- Clay/silt to a maximum depth of 1.70m bgl.
- Silty clayey gravelly sand or silty clayey sandy gravel to a maximum depth of 2.20m bgl.

- Cornbrash Limestone Formation (recovered as dense to very dense light yellowish orange brown gravel in a clay/sand matrix)) to a maximum depth of 3.50m bgl
- Forest Marble Formation (greenish grey variously calcareous silicate siltstone, with lenticular cross-bedded limestone units) to a maximum depth of 9.50m bgl.

Groundwater is reported as being recorded at between 0.31 and 2.02m bgl during the post-fieldwork monitoring.

Apart from anthropogenic material ("macadam", ash, clinker and glass in the Made Ground, no visual or olfactory evidence of contamination was recorded.

Asbestos was identified in six of the 25 samples tested, at concentrations ranging from <0.0001% to 0.929%.

Lead was identified at a concentration in excess of the GAC for commercial land use in one sample of Made Ground. It was also reported that lead had been recorded at concentrations in excess of the GAC for commercial land use in four samples, and nickel in one, in previous investigations.

PAHs (benzo(b)fluoranthene, benzo(a)pyrene and dibenz(a,h)anthracene) were identified at concentrations in excess of the respective GACs in two samples. The exceedances were attributed to macadam/ballast fragments in soil.

150mm of "clean soil'" laid over a high-visibility geotextile layer, is recommended to protect site users from contaminated soils in soft landscaped areas, unless the Made Ground is removed.

Risks to groundwater are reported as low, as risks from ground gas.

Made Ground soils are reported to be highly varied and to require disposal as either hazardous or non-hazardous waste. Natural soils are reported to be suitable for disposal as inert waste.

Soil infiltration rates across the site are reported to range from no infiltration to 7.75 x 10-m/s.

Soils are recorded to be of intermediate to very high plasticity, and have low to moderate potential for volume change.

A Design Sulphate Class of DS-1 and Aggressive Chemical Environment for Concrete Class of ACEC-1 are reported, but are based solely on pH and water-soluble sulfate values, rather than the full SD1 suite.

Spread foundations are recommended for the development, founding below any Made Ground and shallow clay soils, and penetrating at least 150mm into the medium dense or denser gravel of the Cornbrash. An "estimated safe bearing pressure of 250kPa" is recommended for traditional strip or trench-fill foundations up to 1m wide and pad foundations up to 2m square.

It is noted that dewatering may be required as deeper foundations nay penetrate below the water table.

It is recommended that ground floors are constructed on compacted aggregate, following removal of the "upper materials" and proof rolling of the formation.

Reported CBR values range from 4 % to 370% due to the nature of the near surface soils/weathered rock.

Reuse of at least some site-won soils as hardcore in future areas of roads or hardstanding and as general Fill is considered possible, subject to material properties, crushing, screening, and appropriate placement and compaction.

2.3 Site description

The site covers an area of approximately 10.3ha and is a generally flat area of open land, with some local undulations and a number of vegetation-covered mounds. There is an asphalt/tarmac covered car park in the far northwest corner of thew site, and a short section of asphalt/tarmac covered road in the east.

It is bounded to the south west by Skimmingdish Lane, with off-site (third party) commercial units bounding it to the east. The southern airfield perimeter forms the northern boundary, while the western boundary is roughly located at one of the airfield's make-shift car parks.

2.4 Site history

Reference to historical reports indicate the site was predominantly agricultural land from at least 1881, with the former Roman Way (now A4421) to the west., a small quarry to the south-east of the site, and evidence of quarrying in the far north of the site. Hungerford Farm is shown close to the northern quarry; within the site boundary.

A number of buildings are shown on the western site boundary on the 1923 map, although they are no longer shown from 1938.

Although not shown on the OS maps (1938 to 1952) the RAF Bicester airfield and buildings are known to have been present to the north of the site during this period. The airfield is shown from 1955, although the associated buildings are still not shown. Hungerford Farm is not shown on the 1955 map.

Maps from 1968 to the present day show the RAF Bicester buildings, infrastructure and airfield essentially as they currently are.

The report notes that it is known that part of the wider Bicester development site was first occupied by the Royal Flying Corps in 1920 and the RAF in 1928, and used as a logistical centre and training facility by the RAF in World War II. After the war it was used for storage, maintenance, repair and salvage of aircraft and equipment until 1976, when it ceased being an active station. The United States Air Force used the site between 1978 until 1994, then it was used again used by the RAF until 2004.

2.5 Geology

Based on the British Geological Survey (BGS) mapping the geology at the site consists of Cornbrash Limestone Formation (limestone, with thin sandstones and occasional interbeds of mudstone), overlying the Forest Marble Formation (mudstone, possibly sandy, with some limestone and sandstone). Made Ground associated with the construction, remediation and backfilling of the 'catapult pit' and associated trenches, and of the car park, should be anticipated.

No superficial deposits are recorded on site, or in the nearby area.

2.6 Hydrogeology

The Cornbrash Limestone Formation and Forest Marble Formation are classed by the Environment Agency as Secondary A Aquifers.

The Crestwood report identifies ten groundwater abstractions within 2km of the site. The distance to these is not provided, but the closest is recorded as within 150m of the site. All appear to be private abstractions. Two of these are recorded as being for potable water (including the one within 150m of the site), but the site is not within a Source Protection Zone.

2.7 Hydrology

The nearest surface water feature is a Audley Brook approximately 150m to the north-west of the site, which drains into Langford Brook approximately 550m to the east.

The Crestwood report identifies one surface water abstractions within 2km of the site. Again, the distance to this abstraction is not provided.

2.8 Flood risk

The desk study information and Hydrock's own data indicates the proposed development is in Flood Zone 1 (with a low probability of flooding from rivers or the sea).

No further consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regard to drainage and flooding.

2.9 Mining or mineral extraction

The provided reports indicate that the central area of the site is a former quarry, now infilled.

The area of the former landfill, as interpreted by Grontmij, is shown on its 'RAF Bicester Phase 2. Phase II Land Quality assessment (LQA) Technical Note – Figure 2B. Old Dump Site: Site Layout and Exploratory Hole Location Plan', a copy of which is presented in Appendix C.

2.10 Waste management

There are no waste management sites recorded within 250m of the site. However, it is known that the former quarry in the centre of the site was historically used for uncontrolled tipping. Waste materials are recorded to comprise a generally clay based material containing various proportions of metal, glass, ash, coal, bricks, concrete, limestone and porcelain.

2.11 Regulatory information

The Crestwood desk study does not identify any sites within 2km that have regulatory controls relevant to the site.

2.12 Natural soil chemistry

The Crestwood desk study did not identify any significantly elevated naturally occurring elements that may present a risk to future site users.

2.13 Radon and ground gas

The site is not in a Radon Affected Area, with recorded radon levels in 1-3% of homes above the action level, so no radon protection measures are required for new buildings at this location in line with current guidance.

2.14 Unexploded ordnance (UXO)

A specialist UXO risk assessment was undertaken as part of the Crestwood (2018) desk study and concluded that the risks to development workers and site users from unexploded Ordnance (UXO) was moderate-low. Subsequently, a 'Detailed UXO Risk Assessment' (Fellows (2020) ref. 2979R) was undertaken and provided to Hydrock for review.

The Fellows UXO risk assessment indicates:

- The risk of encountering UXO is greater in the south of the site than the north.
- The northern area of the site is only approximately 500m away from former bomb storage area.
- The risk of encountering deep buried German aerial UXO is assessed to be low.

- The risk of encountering Allied air service ordnance is assessed as medium.
- The risk of encountering Allied air defence ordnance is assessed as low.
- The risk of encountering small arms ammunition (cannon shells and pyrotechnics) is assessed as medium.
- Specific procedures, training, briefings and permitting is required for all excavation works. These are to comprise:
- UXO safety awareness training of site personnel and project staff.
- A non-intrusive site survey using electromagnetic pulse induction (EM) or magnetometry to identify shallow buried targets (to a depth of approximately 3m bgl) within the works area (if any).
- Site supervision of excavations and earthworks by a UXO engineer
- Preparation of a site-specific emergency response plan in the event of encountering UXO, which should be included in the health and safety plan for the proposed works and communicated to the work force at the operational level, typically as part of a toolbox talk.

A copy of the UXO desk study is included in (see Appendix C).

3. Initial conceptual site model

3.1 Introduction

The initial Conceptual Site Model (CSM) incorporates evidence from the site walkover, the Desk Study and previous investigations carried out at the site. The formulation of an initial CSM is a key component of the LCRM methodology, and incorporates: a ground model of the site physical conditions; and an exposure model of the possible contaminant linkages. It forms the basis for Generic Quantitative Risk Assessment (GQRA) in accordance with current guidelines.

3.2 Ground model

The preliminary ground model presented in Sections 2.5 to 2.13 provides an understanding of the ground conditions and is the basis for preparing the preliminary geotechnical hazard assessment (Section 3.3) and the preliminary geo-environmental exposure model (Section 3.4).

3.3 Geotechnical hazard identification

3.3.1 Context

The preliminary geotechnical hazard identification has been undertaken in accordance with the general requirements of ICE/DETR Document 'Managing Geotechnical Risk' and the HE documents HD 41/15 and CD 622.

The following section sets out the identified geotechnical hazards and the development elements potentially affected (see Table I.1 in Appendix I for further information).

3.3.2 Plausible geotechnical hazards

Plausible geotechnical hazards identified at the site are:

- Uncontrolled Made Ground (variable strength and compressibility).
- Shrinkage/swelling of the clay fraction of soils under the influence of vegetation.
- Lateral and vertical changes in ground conditions.
- Attack of buried concrete by aggressive ground conditions.
- Obstructions.
- Existing below ground structures to remain.
- Shallow groundwater.
- Changing groundwater conditions.
- Loose Made Ground, leading to difficulty with excavation and collapse of side walls.
- Earthworks – poor bearing capacity of new fill.
- Earthworks – unsuitability of site-won material to be reused as fill.

3.3.3 Potential development elements affected

Development elements potentially affected by geotechnical hazards are:

- Buildings – foundations.
- Buildings – floor Slabs
- Roads and pavements.
- Services.
- Landscape Areas.

- Construction staff, vehicles and plant operators.
- Concrete below ground.
- Earthworks control, inability to place and compact fill.
- Insufficient fill to complete earthworks.

Health and safety risks to site Contractors and maintenance workers have not been assessed during these works and will need to be considered separately during design.

The above plausible geotechnical hazards and development elements affected have been carried forward for investigation and assessment. The investigation is presented in Section 5 and the assessment is presented in Section 6.

3.4 Geo-environmental exposure model

3.4.1 Context

The preliminary exposure model is used to identify geo-environmental hazards and to establish potential contaminant linkages, based on the source-pathway-receptor (SPR) approach.

A viable contaminant linkage requires all the components of an SPR to be present. If only one or two are present, there is no linkage and no further assessment is required.

3.4.2 Potential contaminants

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from an on-site or off-site source.

3.4.2.1 Potential on-site sources of contamination

- Made Ground, associated with historical construction activities and imported fill, possibly including metals, metalloids, asbestos fibres, Asbestos Containing Materials, PAH and petroleum hydrocarbons (S1).
- Made Ground in the former landfill/'old dump' area, possibly including metals, metalloids, asbestos fibres, Asbestos Containing Materials, PAH and petroleum hydrocarbons (S2).
- Hydrocarbon fuels, lubricants, and solvents from the operation of the former airfield including leakage from Underground Storage Tanks (USTs), Above Ground Storage Tanks (ASTs), the pipework between tanks and pumps, and general spillage, together with uncontrolled disposal and spillage from waste receptacles (S3).
- Coal tar in bituminous bound pavements associated with the former airfield (S4).
- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground in the former landfill/'old dump' (S5).
- Hydrocarbon vapours from potential VOC and petroleum hydrocarbon spillages/leaks (S6).
- Asbestos from demolition of former buildings (S7).

3.4.2.2 Potential off-site sources of contamination

- Made Ground, associated with historical construction activities and imported fill, possibly including metals, metalloids, asbestos fibres, Asbestos Containing Materials, PAH and petroleum hydrocarbons (S8).
- Hydrocarbon fuels, lubricants, and solvents from the operation of the former airfield including leakage from Underground Storage Tanks (USTs), Above Ground Storage Tanks (ASTs), the pipework between tanks and pumps, and general spillage, together with uncontrolled disposal and spillage from waste receptacles (S9).
- Hydrocarbon vapours from potential VOC and petroleum hydrocarbon spillages/leaks (S10).

» Asbestos from demolition of former buildings (S11).

3.4.3 Potential receptors

The following potential receptors in relation to the proposed land use have been identified.

» People (site users, neighbours) (R1).
» Groundwater: Secondary A aquifer status of the River Terrace Deposits (R2).
» Surface water: on-site drainage ditch and ponds 450m to the south (R3).
» Development end use (buildings, utilities and landscaping) (R4).

3.4.4 Potential pathways

The following potential pathways have been identified.

» Ingestion, skin contact, inhalation of dust and indoor and outdoor air by people (P1).
» Methane ingress via permeable soils and/or construction gaps (P2).
» VOC and petroleum hydrocarbon vapour ingress via permeable soils and/or construction gaps (P3).
» Migration of contaminants through the unsaturated zone into the groundwater in the Cornbrash/Forest Marble aquifer(s) (P4).
» Abstraction and consumption by people (or other utilisation) of groundwater (P5).
» Surface water via base flow from groundwater (P6).
» Surface water via overland flow (P7).
» Surface water, via drainage discharge (P8).
» Direct contact with substances deleterious to building materials (P9).
» Root uptake by plant (P10).
» Methane ingress to the root zone from the landfill site, by plants (P11).

Health and safety risks to site development contractors and maintenance workers have not been assessed as part of this study and will need to be considered separately.

The above sources, pathways and receptors have been considered as part of the Preliminary Risk Assessment in accordance with LCRM (2023), are considered to be plausible in the context of this site and have been carried forward for investigation and assessment. The investigation is presented in Section 4 and the assessment is presented in Section 7 An assessment of the Source – Pathway – Receptor linkages is undertaken following the assessment (Section 7) and is presented in Appendix J (Table J.1).

3.4.5 Potential implications of climate change

Climate change has the potential to change the risk profile for conceptual site models and associated contaminant linkages. The impact of climate change on the CSM is site-specific, and a qualitative assessment of the potential impact of climate change on the CSM for this site is summarised below. The assessment has primarily utilised the guidance in Environment Agency (2010)[2] and SoBRA (2022)[3] which set out the UK context to climate change and land contamination.

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[2] Environment Agency, 2010. Guiding Principles for Land Contamination. Part 2. FAQs, technical information, detailed advice and references, March 2010.

[3] SoBRA, 2022. Guidance on Assessing Risk to Controlled Waters from UK Land Contamination Under Conditions of Future Climate Change, Society of Brownfield Risk Assessment, August 2022.

Both guidance documents advocate a 'what if' scenario approach in the context of changes in ambient temperatures, an increase in the frequency of extreme rainfall/storm events and heatwaves/droughts, and long-term changes in groundwater and sea levels.

Those 'what if' scenarios that are relevant to this CSM are:

- Increased long-term rainfall leading to increased infiltration and seasonally higher groundwater and water levels in surface waters.
- Increased frequency and/or magnitude of extreme rainfall events leading to short-term surface flooding, surface water run-off, groundwater flooding, and/or land-based erosion.
- Increased frequency and/or magnitude of storm events leading to short-term drops in barometric pressure and/or high winds.
- Occurrence of extreme cold and hot weather events leading to changes in ground conditions such as soil temperature, evapo(trans)piration, and soil moisture (for example freeze-thaw effects and desiccation), decreased infiltration and fall in groundwater and surface water levels.

4. Ground investigation

4.1 Site works

The ground investigation works, including the rationale which was based on the findings of the preliminary risk assessment is summarised in **Error! Reference source not found.**. For the investigation rationale of the historical investigations, please refer to the historical reports in Appendix C.

The fieldwork took place between 10 and 12 October 2023. The ground investigation locations were surveyed in using a topographic survey quality GPS [and are shown on the Exploratory Hole Location Plan (Hydrock Drawing 27280-HYD-XX-XX-DR-GE-1002_S2-P01) in Appendix A.

The logs, including details of ground conditions, soil sampling, *in situ* testing and any installations, are also presented in Appendix DD.

Table 4.1: Summary of site works

Activity	Method	No.	Name	Depth Range (m bgl)	*In situ* tests	Rationale
Boreholes	Windowless sampler	10	WS101 to WS110	0.57 – 1.45	Standard Penetration Tests (SPT)	To investigate strength of Cornbrash
Trial pits	Machine (JCB 3X)	13	TP101 to TP113	0.60 – 3.10	Hand shear vane (HSV)	To confirm ground conditions and investigate areas not covered by earlier investigations

Wells for monitoring groundwater levels and ground gas concentrations, and to facilitate the sampling of groundwater, were installed in six of the windowless sampler boreholes. A summary of the monitoring well installations is presented in Table 4.2.

Table 4.2: Summary of monitoring installations

Location	Ground level (m OD)	Standpipe diameter	Screen top and base depth (m bgl)	Screen top and base elevation (m OD)	Strata targeted
WS101	67.05	50	0.50 – 1.00	77.12 – 77.62	Made Ground
WS102	67.52	50	0.40 – 0.70	76.43 – 76.73	Cornbrash Limestone Formation
WS103	70.76	50	0.40 – 0.70	75.93 – 76.23	Made Ground
WS104	70.86	50	0.50 – 070	74.99 – 75.19	Cornbrash Limestone Formation
WS106	70.76	50	0.80 – 1.45	74.25 – 74.90	Cornbrash Limestone Formation

WS107	70.86	50	0.30 – 0.70	73.57 – 73.97	Cornbrash Limestone Formation

4.2 Geo-environmental testing

4.2.1 Sampling strategy and protocols

Exploratory hole positions were determined by reference to the site conditions and uncertainties identified in the Initial Conceptual Model. In particular the area of the former landfill/'Old dump' and areas in the north-west of the site, which had not been covered ion previous investigation were targeted.

No specific sampling statistics or grid were utilised in this instance.

Samples were taken, stored and transported in general accordance with BS 10175:2011+A2:2017.

4.2.2 Geo-environmental monitoring

Gas monitoring boreholes have been monitored on six occasions. The results are presented in Appendix F

4.2.3 Geo-environmental laboratory analyses

The certificates for chemical analysis undertaken as part of Hydrock's investigation are provided in Appendix G and summarised in the table below. Wherever possible, UKAS and MCERTS accredited procedures have been used.

The certificates for chemical analysis undertaken as part of historical investigations are provided in the relevant reports in Appendix CC.

The geo-environmental analyses undertaken by Hydrock on soils are summarised in Table 4.3.

Table 4.3: Geo-environmental analyses of soils

Determinand Suite	Made Ground/ Made Ground Topsoil	Made Ground Landfill	Cornbrash	Forest Marble
Hydrock minimum suite of determinands for solids*	7	4	3	1
Speciated aliphatic and aromatic banding Total petroleum hydrocarbons by HS-GC/MS and GC/FID (Hydrock Tier 2 TPH Suite)	3	2	-	-
Benzene, toluene, ethylbenzene and xylene (BTEX) by HS-GC/MS	3	2	-	-
Waste Acceptance Criteria (WAC) leachate	-	1	-	-
Topsoil Suite (BS3882:2015)	1	-	-	-
*Hydrock minimum soil suite comprises: As, B (water soluble), Be, Cd, Cr (total), Cr (VI), Cu, Hg, Ni, Pb, S (elemental), Se, V, Zn, cyanide (total), sulfide, pH, asbestos fibres, speciated polynuclear aromatic hydrocarbons (PAH, by GC-FID), total phenols and fraction of organic carbon				

Two samples of suspected coal tar were also analysed for speciated PAH.

The soils chemical test data (including both Hydrock and historical data) are interpreted and assessed in Section 7

4.3 Geotechnical laboratory testing

The geotechnical tests undertaken by Hydrock are summarised in Table 4.4 and the test certificates are provided in Appendix E. Wherever possible, UKAS accredited procedures have been used.

The geotechnical tests undertaken as part of historical investigations are provided in the relevant reports in Appendix C.

Table 4.4: Geotechnical tests

Test	Made Ground	Made Ground Landfill	Cornbrash	Forest Marble
Natural moisture content	2	3	4	1
Atterberg limits	2	3	4	1
Particle density	-	1	1	1
Particle Size Distribution (PSD)	-	2	2	1
Triaxial Undrained Shear Strength				
Laboratory Shear Vane (set of five tests) on compacted material	-	1	1	1
Dry Density/Moisture Content Relationship	-	1	1	1
California Bearing Ratio	-	1	1	1
Sulfate and aggressive chemical environment classification for buried concrete classification (full BRE SD1 suite)	1	-	6	-

The geotechnical test data (including both Hydrock and historical data) are summarised in Section 5.5 and interpreted in Section 6.

5. Ground investigation records and data

5.1 Physical ground conditions

5.1.1 Summary of strata encountered

The following presents a summary of the properties of the ground and groundwater conditions encountered, based on field observations, interpretation of the field data and laboratory test results, taking into account drilling, excavation and sampling methods, transport, handling and specimen preparation.

All relevant data from the Hydrock investigation discussed in Section 4 as well as any reliable data from previous investigations noted in Section 1.4 and discussed in Section 2.2 are used from this point forward.

Details of the Hydrock ground investigation works are provided in the logs in Appendix D, previous data are provided in Appendix C , a summary of the ground model is presented in Table 5.1 and the individual strata are described in the sections below. Relevant contour plans are presented in Appendix A

Table 5.1: Strata encountered

Stratum	Depth to top (m bgl)	Depth to base (m bgl)	Proven Thickness (m) (range)	Thickness (m) (average)
Made Ground Topsoil[4]	0.00	0.10 - 0.70	0.10 - 0.70	0.25
Made Ground[5]	0.00 – 0.15	0.10 – 1.00	0.05 – 1.00	0.30
Made Ground Landfill	0.00 - 0.15	0.25 – 2.20	0.25 – 2.20	0.97
Cornbrash[6]	0.10 – 1.00	>0.57 – >3.50	>0.10 – >1.80	-
Forest Marble (Hydrock TP103 and Ridge BH01, BH02 only)	2.00 – 2.80	>3.10 - >9.00	>1.10 – >6.20	-

5.1.2 Made Ground

Three types of Made Ground: are identified:

- Made Ground Topsoil generally comprising soft slightly sandy, slightly gravelly clay, with frequent roots and rootlets and occasional to rare fragments of brick, glass, ash, slag, asphalt and coal or slightly gravelly, locally clayey, locally sandy and locally slightly peaty silt, with rare to occasional brick, 'ballast' and 'macadam' fragments (Ridge holes only).
- Made Ground comprising variously:
  - cobbles and boulders of limestone with occasional fragments of asphalt;
  - slightly sandy, slightly clayey gravel;
  - brick rubble with silt/clay;

[4] A number of boreholes and trial pits from the Ridge ground investigation record Topsoil, but this has been reinterpreted following the Hydrock ground investigation as Made Ground Topsoil.

[5] The Ridge GIR does not distinguish Made Ground Topsoil, general Made Ground and Made Ground Landfill, so this may include some of those 'strata'.

[6] Includes materials described by Ridge as "clay/silt", "silty clayey gravelly sand" or "silty clayey sandy gravel", but not identified as a particular stratum. Hydrock considers these materials to weathered Cornbrash.

- very soft to firm slightly sandy slightly gravelly clay, with frequent fragments of limestone, brick, ash, asphalt and glass, and locally a low cobble content.

- Made Ground Landfill comprising variously:
  - very sandy gravel with occasional fragments of asphalt;
  - clayey sandy gravelly silt or clay/silt with some 'macadam', clinker, brick, glass, ironstone and ash;
  - limestone gravel with occasional fragments of 'macadam/ballast';
  - brick rubble with silt/clay;
  - silty, sandy very gravelly clay, with occasional gravel, cobbles and boulders of brick, concrete, tile and metal and rare complete concrete slabs and sections of brickwork.

In addition, there is an asphalt/tarmac covered car park in the north-west of the site and a short section of asphalt/tarmac covered road in the east.

More details of the different Made Ground lithologies are given on the logs in Appendix D and the historical investigation reports in Appendix C.

The assessed extent of the Made Ground and Made Ground - Landfill is shown on drawing 27280-HYD-XX-XX-DR-GE-1010 and HYD-XX-XX-DR-GE-1012 in Appendix A.

5.1.3 Cornbrash Limestone Formation

Cornbrash Limestone Formation (Cornbrash) was encountered underlying the Made Ground in all areas of the site except in Hydrock trial pit TP103 (where Forest Marble was recorded directly below the Made Ground Landfill), to approximate depths of between 0.60m and 3.50m bgl, although many of the exploratory holes were terminated in this stratum, due to its strength.

The Cornbrash is described as a strong light brown/yellowish brown very thinly bedded ooidal shelly limestone, generally recovered as a clayey or silty fine to coarse gravel with some cobbles and boulders (lithorelicts and fragments) of limestone.

5.1.4 Forest Marble Formation

Forest Marble Formation (Forest Marble) was encountered directly underlying the Landfill Made Ground in Hydrock trial pit TP103, and below the Cornbrash in all the Ridge cable percussion boreholes. All holes where the Forest Marble was encountered were terminated in this stratum

Forest Marble was recorded as stiff to very stiff grey silt, with occasional shell fossils and angular siltstone lithorelicts in Hydrock trial pit TP103, and as stiff to very stiff grey fissured clay interbedded with strong to very strong bluish gey limestone in Ridge boreholes BH01 to BH03.

5.2 Obstructions

Whilst man-made obstructions were not encountered during the investigations, cobbles, boulders and sections of brickwork were noted in several locations in the Made Ground Landfill. Furthermore, all of the trial pits and windowless sampler boreholes were terminated at relatively shallow depth on either dense/very dense 'gravel' of fractured, weathered limestone, or on intact rock strata.

5.3 Groundwater

5.3.1 Groundwater observations and levels

Groundwater encountered during the investigation is listed in Table 5.2. A groundwater observation represents the depth at which groundwater was first observed and is likely to be deeper than the actual water table level at that location.

Table 5.2: Groundwater entries

Stratum	Date	Location	Groundwater observation (m bgl)	Comment
Cornbrash	12/05/21	WS04	1.40	-
	12/05/21	WS06	1.00	-
	11/05/21	WS07	1.00	Seepage at base of hole.
	11/05/21	WS13	1.50	Seepage at base of hole.
	11/10/23	TP103	2.50	Moderate inflow, leading to spalling of trial pit faces.
	12/10/23	TP106	1.70	Moderate inflow,
	10/10/23	WS107	1.00	Seepage at base of hole.

Groundwater levels recorded during post-fieldwork monitoring are summarised in Table 5.3.

Table 5.3: Groundwater level summary

Stratum	Date range	Location	Post-fieldwork monitoring	
			Depth to groundwater (range) (m bgl)	Groundwater elevation (range) (m OD)
Made Ground	26/10/23 – 29/11/23	WS101	0.50 - 0.88	77.26 - 77.62
Made Ground/ Cornbrash	26/10/23 – 29/11/23	WS103	0.70 - Dry	75.88
Cornbrash	25/05/21 – 25/06/21	WS01 WS03 WS06 WS07 WS12 WS15	0.59 – 1.54 1.28 – 2.02 0.74 – 1.96 0.31 – 1.10 1.01 – >1.60[7] 1.35 - >2.45[7]	75.36 – 74.41 74.46 – 73.72 73.27 – 72.05 72.94 – 72.15 74.28 - <73.69 71.77 - <70.67
	26/10/23 – 29/11/23	WS104 WS106 WS107	Dry (0.45m) 1.21 – 1.29 0.30 - 0.90	Dry 74.73 73.37 – 73.97
Cornbrash/ Forest Marble	25/05/21 – 25/06/21	BH01 BH04	1.18 – 1.76 1.12 – 1.64	74.56 – 73.98 71.83 – 71.31
Forest Marble	25/05/21 – 25/06/21	BH03	1.35 – 1.64	72.93 – 72.64

[7] Recorded as 'Dry'

5.3.2 *Infiltration tests*

The results of the infiltration testing undertaken as part of the Ridge investigation are presented in the Ridge ground investigation report in Appendix C. Results ranged from 1.6 to 7.8 x 10^{-5} m/s.

It should be noted that historical infiltration tests were undertaken in summer, and no comment was provided with regard to groundwater levels.

5.3.3 *Groundwater summary*

Shallow groundwater was encountered in the Cornbrash during the fieldwork, although many of the shallowest holes did not encounter groundwater at all during excavation. However, the Ridge boreholes BH01 to BH04 were drilled using rotary techniques, with water flush, which would have masked any groundwater entries.

Water levels post-fieldwork from both investigations indicate a shallow groundwater table generally at between approximately 0.50m and 1.50m bgl.

5.4 Ground gases (carbon dioxide and methane)

Records from the gas monitoring boreholes are presented in Appendix F and summarised in Table 5.4.

Six monitoring visits were undertaken as part of the Ridge investigation and a further six as part of the Hydrock investigation. The data are assessed in Section 7.7

Table 5.4: Range of ground gas data

Stratum	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Steady flow rate (l/hr)	Comment
Made Ground	<0.1[8]	0.1[8] – 1.2	17.2 – 20.3	0.1	-
Cornbrash	<0.1[8] – 0.1	<0.1[8] – 4.9	15.5 – 22.1	-0.1 – 0.2	-
Cornbrash/Forest Marble	<0.1[8] – 0.1	0.1 – 4.7	10.6 -19.5	0.0 – 0.1	-
Forest Marble	<0.1[8] –	0.1 – 1.4	9.2 - 21.8	0.0 - 0.2	-

5.5 Geotechnical data

5.5.1 *Introduction*

In situ test results are shown on the relevant exploratory hole log or datasheet in Appendix D, with laboratory test results presented in Appendix E. The following sections summarise the main findings and provide interpretation where appropriate.

5.5.2 *Plasticity*

The volume change potential of the soils in terms of BRE Digest 298 with respect to building near trees have been determined from the results of plasticity index tests on samples of soil. These are summarised in Table 5.5.

[8] Concentration below detection limit of monitor,

Table 5.5: Volume change potential

Stratum	No. of tests	Plasticity Index			Modified Plasticity Index			Plasticity designation	Volume Change Potential
		Min.	Max.	Av.	Min.	Max.	Av.		
Made Ground[9]	2	25	27	26	23	24	24	Intermediate to high	Medium
Made Ground Landfill[9]	3	18	29	25	5	18	12	High	Non-shrinkable to low
Cornbrash	8	17	31	23	16	26	23	Intermediate	Low to medium
Forest Marble	5	16	35	26	10	35	24	High to very high	Low to medium

5.5.3 *Particle size distribution*

Particle Size Distribution test (PSDs) results are summarised in Table 5.6 and summary descriptions and PSD plots of the material analysed are presented in Appendix E.

Table 5.6: PSD results summary

Stratum	No. of tests	Silt/ Clay %	Sand %	Gravel %	General description
Made Ground Landfill[9]	2	17 - 39	15 - 19	42 - 68	Slightly sandy gravelly to very gravelly very silty clay/silt to clayey slightly sandy gravel (mixed Made Ground)
Cornbrash	7	1 - 37	5 - 35	34 - 94	Slightly sandy to sandy gravelly to very gravelly very silty clay/silt to slightly clayey slightly sandy to sandy gravel (weathered limestone)
Forest Marble	1	35	15	50	Slightly sandy very gravelly silt/clay (weathered mudstone/siltstone)

[9] Highly variable material. Use values with caution.

5.5.4 Soil strength

Table 5.7 summarises information pertaining to the shear strength of the soils according to geological stratum. Because the Cornbrash and Forest Marble encountered are essentially weathered and heavily fractured rock strata it is considered inappropriate to correlate shear strength with SPT values, as these would be unlikely to provide representative results.

Table 5.7: Soil strength results

Stratum	No. of tests	c_u (kPa)	Method
Cornbrash	1	52	Hand shear vane
Forest Marble	1	93	Hand shear vane

Table 5.8 summarises information pertaining to the shear strength of remoulded soils.

Table 5.8: Soil strength results (remoulded samples)

Stratum	No. of Tests	c_u (kPa)	Method
Made Ground Landfill[10]	1	66	Laboratory triaxial test on sample remoulded at Optimum Moisture Content (OMC)
	5	118 - >150	Laboratory vane over moisture content range OMC-5% to OMC+6%
Cornbrash	1	77	Laboratory triaxial test on sample remoulded at OMC
	5	106 - >150	Laboratory vane over moisture content range OMC-4% to OMC+6%
Forest Marble	1	79	Laboratory triaxial test on sample remoulded at OMC
	5	46 - >150	Laboratory vane over moisture content range OMC-5% to OMC+6%

5.5.5 Relative density

Whilst not strictly applicable, as the Cornbrash and Forest Marble encountered are essentially weathered and heavily fractured rock strata rather than granular soils, Table 5.9 summarises information pertaining to the relative density of the soils according to geological stratum.

Table 5.9: Relative density results and derived values

Stratum	No. of tests	SPT (N-value) (Range)	phi' (°)	Method
Made Ground[11]	1	33	36	SPT correlation– windowless sampler boreholes (Hatanaka and Uchida (1980).
Made Ground Landfill[11]	5	7 - 6	25	
Cornbrash	36	25 - >50	35	

[10] Highly variable material. Use values with caution.

[11] Highly variable material. Use values with caution.

Stratum	No. of tests	SPT (N-value) (Range)	phi' (°)	Method
Forest Marble	9	48 - >50	40	SPT correlation– windowless sampler boreholes (Hatanaka and Uchida (1980).

5.5.6 Compaction and moisture content

Table 5.10 presents a summary of the moisture content tests and compaction studies undertaken at the site.

Table 5.10: Compaction study results

Stratum	No. of tests	Method	Natural moisture content (%)	Optimum Moisture Content (%)	Particle Density (Mg/m^3)	Maximum Dry Density (Mg/m^3)
Made Ground – Topsoil	1	4.5kg Rammer	17	14	2.48	1.79
Cornbrash	1		13	14	2.69	2.05
Forest Marble	1		23	10	2.68	1.89

5.5.7 Subgrade stiffness

The subgrade stiffness (CBR and Subgrade Surface Modulus) results are summarised in Table 5.11.

Table 5.11: CBR results and derived values

Stratum	No. tests	Method	Subgrade Surface Modulus (r) (MPa) (Range)	CBR (%) (Range)
Made Ground – Topsoil	1	Laboratory remoulded sample at Optimum Moisture Content (OMC)	93	25.1
Made Ground	2	Correlation in accordance with CD 255 based on plasticity and thin construction	27 - 32	3 - 4
Made Ground - Landfill	3	Correlation in accordance with CD 255 based on plasticity and thin construction	27 - 32	3 - 4

Stratum	No. tests	Method	Subgrade Surface Modulus (r) (MPa) (Range)	CBR (%) (Range)
Cornbrash	8	Correlation in accordance with CD 255 based on plasticity and thin construction	27 - 32	3 - 4
	1	Laboratory remoulded sample at Optimum Moisture Content (OMC)	70	15.2
Forest Marble	5	Correlation in accordance with CD 255 based on plasticity and thin construction	27 - 32	3 - 4
	1	Laboratory remoulded sample at Optimum Moisture Content (OMC)	64	13.2
Where using the IAN method, 'k' has been back calculated from the Equivalent CBR.				

TRL DCP tests undertaken by Ridge recorded a minimum value of 4% at 0.25m bgl, 7% at 0.50m bgl and 7% at 0.75m bgl, although generally higher.

5.5.8 *Sulfate content*

In accordance with BRE (Special Digest 1), the Design Sulfate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 5.12. The assessment summary sheets are presented in Appendix E.

Table 5.12: Aggressive chemical environment concrete classification

Stratum	No. tests	DS	ACEC
Made Ground	1	DS-1	AC-1
Cornbrash	17	DS-1	AC-1
Forest Marble	4	DS-1	AC-1

5.5.1 *Intact material strength – rock*

Table 5.13 summarises information pertaining to the strength of the intact rock material (not rock mass) according to geological stratum and, if applicable, weathering zones or other variations within particular strata.

Factual results are summarised for laboratory and field tests. Where point load index tests are used to infer unconfined compressive strength (UCS), this is also tabulated. Rock strength terms follow the method of BS EN ISO 14689-1:2003.

Care should be exercised in using these assumed rock strength parameters for any purpose beyond the scope of this report, because it may be that additional sampling and testing is required for certain purposes. The reader should refer to the original test results in Appendix E. Note also that rock mass properties, rather than intact rock material properties, may be more suitable for design purposes.

Table 5.13: Intact rock strength results and derived values

Stratum	No. of tests	Point load index (Range)		Intact shear strength (range)		UCS (MPa) (range)	Method
		Is	$Is_{(50)}$	c' (MPa)	phi'(°)		
Cornbrash	2	1.03 – 1.44	1.07 – 1.14	-	-	-	Axial point load
Forest Marble	3	0.20 – 0.44	0.26 – 0.57	-	-	-	Axial point load
	3	-	-	-	-	20.6 – 55.5	UCS test

6. Geotechnical assessment

6.1 Geotechnical categorization of the proposed development

Eurocode 7, Section 2 advocates the use of geotechnical categorization of the proposed structures to establish the design requirements.

The proposed development is shown on 3D Reid drawing 'Proposed Site Plan Phase 2' reference 220127-3DR-ZZ-00-DR-A-07008, and comprises nine warehouse units (B1 – B9) totalling 10,000m^2, with associated external service yards, 360 parking spaces, access roads and infrastructure. A number of screening mounds are shown in the south of the site with a minimal cut and fill exercise needed as part of the works.

Based on the above, for the purposes of this investigation, the proposed structures have been classed as Geotechnical Category 2.

For Category 2 structures, the Geotechnical Category should be reassessed at the design stage and specific geotechnical design (in addition to this investigation) is required.

Following ground investigation and as part of the assessment provided in the following section, the preliminary geotechnical hazard identification undertaken in Section 3.3 has been updated.

Assessment has been undertaken in accordance with the general requirements of ICE/DETR Document 'Managing Geotechnical Risk' and the HE documents HD 41/15 and CD 622. The preliminary Geotechnical Risk Register following investigation is provided in Appendix I (Table I.3) and will need to be updated during future design works.

6.2 Characteristic design values

In accordance with BS EN ISO 1997-1 (EC 7), Hydrock consider the proposed structures would be classified as Category 2 structures. As part of the separate geotechnical design, the designer should determine the geotechnical design values.

Table 6.1 provides characteristic geotechnical values to assist the designer. These are based on laboratory testing, *in situ* testing and by professional judgement using published data together with knowledge and experience of the ground conditions. Care should be exercised in using these assumed soil strength parameters for any purpose beyond the scope of this report because it may be that additional sampling and testing are required for certain purposes. The reader should refer to the original test results summarised in Section 5 and provided in Appendix D and Appendix E.

Table 6.1: Characteristic geotechnical values

Parameter Stratum	Bulk unit weight kN/m^3 γ [a]	Effective angle of internal friction ° φ' [b c]	Undrained shear strength **kN/m^2** c_u	Modulus of subgrade reaction **MN/m^2/m** k [d]
Cornbrash (fine)	18 - 22	26	120	27
Forest Marble (fine)	18 - 22	26	120	27

a. Estimated based on the recommendations of BS 8004-2015.
b. Internal friction (φ') values for the granular in situ material derived from SPT data following the recommendations of Peck et al., (1967).
c. Internal friction (φ') values for the cohesive *in situ* material derived from BS 8004-2015, where $\varphi cv'$ is derived from plasticity index. The use of $\varphi cv'$ in the analysis is considered to provide a conservative estimate of φ'.
d. Based on the equilibrium long term CBR from DMRB IAN 73/06 Rev 1 Table 5.1.

6.3 Groundwork

6.3.1 Site preparation

Whilst no buried obstructions were encountered by this investigation, the possibility of buried obstructions being encountered remains, with pill boxes and 'seagull trenches' present in the north of the site, for example. Furthermore, there are rock quality strata at shallow depth across the site, which prevented excavation of deep trial pits. Therefore, it is recommended that an allowance be made for breaking out obstructions, for example provision of pneumatic breakers for site plant. If underground structures cannot be removed, they will need to be surveyed in three dimensions and the new structures will need to be designed to accommodate them.

Topsoil should be removed from beneath all building footprints and hardstanding areas.

6.3.2 Groundworks

Following breaking out of any hardstanding and obstructions, excavation of shallow soils should be readily undertaken by conventional plant and equipment. However, excavation through any intact rock quality strata may require heavy-duty excavation plant/ripping plant, or the use of specialist breaking equipment.

Trial pit faces were noted generally to remain vertical without collapse, although spalling of the faces of trial pit TP103 was noted when water was encountered at 2.50m bgl. Therefore, whilst the faces of shallow, near vertically sided excavations put down at the site generally are likely to remain stable for short periods of time, temporary trench support, or battering of excavation sides, is recommended for all excavations that are to be left open for any length of time and will definitely be required where man entry is required. Particular attention should be paid to excavation at, or close to, site boundaries/adjoining existing roads/structures/buildings, where collapse of excavation faces could have a disproportionate effect.

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practise in and around open excavations. Further guidance on responsibilities and requirements for working near, and in, excavations can be obtained from the Construction Design and Management Regulations (2015); Construction Information Sheet 47: Inspections and Reports (2005) and HSG47: Avoiding Danger from Underground Services.

To ensure no loads are imposed on the sides of the excavation, spoil should not be placed immediately adjacent to the excavation. Spoil should be placed a suitable distance from the side of the excavation (as assessed by a competent person).

Based on site observations, the rate of water ingress to the proposed excavations is likely to be slow. In these circumstances, groundwater control by sump pumping is likely to be sufficient. However, it should be recognised that groundwater levels may vary from those at the time of the investigation, for example in response to seasonal fluctuations and the timing of construction may dictate the extent of groundwater control required.

Any water pumped from excavations may need to be passed via settlement tanks (to reduce suspended solids) before being discharged to the sewer. Discharge consents may also be required.

6.3.3 *Earthworks/reuse of site-won materials*

It is Hydrock's understanding that new structures are to be founded on either Structural Fill or natural soils. On this basis, within building footprints and the zone of influence of any foundations all Made Gound should be removed and replaced with structural fill, or new foundations are to be carried down to found in natural soils. If the latter, treatment of Made Ground below the floor slab is likely to be required.

It is understood that generally up to 1.5m of cut (up to 3.0m where on-site stockpiles are to be removed) and up to 1.5m of fill are required to form the final development platform, as indicated on Hydrock drawing 27280-HYD-OO-ZZ-DR-C-7400-S2-P01. However, if there is deep Made Ground below building footprints and/or the zone of influence of any foundations, deeper cut may be required to remove it and replace it with suitable structural fill.

Site levels should be left 600mm below finished level to allow placement of a cover system in soft landscaped areas.

Landfill – Made Ground is not to be reused on site, and is therefore currently not included in the cut-fill balance calculations.

The classification of materials depends on both the proposed end use and whether the material will meet the performance requirements of that end use. Based on Hydrock's understanding, the following assessment is based on General Fill for external yard areas and Structural Fill for the building footprints.

An initial assessment of classification data (see Section 5.5 and Appendix E) has been completed based on Hydrock's understanding of the development and the potential to reuse site-won materials as an engineered fill material. This is summarised in Table 6.2.

Table 6.2: Preliminary earthworks assessment

Stratum	Proposed end use	Preliminary classification (SHW Series 600)	Comment	Suitability for improvement by the inclusion of binders
Made Ground - Topsoil	Open Space	Class 4 Landscape Fill	Soils may be reused but only under an engineered cover system due to asbestos fibres in the soil. Cannot be used in areas sensitive to settlement.	Not necessary for landscape fill.
Made Ground	External Areas	Class 4 Landscape Fill	Can only be used in areas which are not sensitive to settlement (unless processed and reclassified).	Not necessary for landscape fill. Generally low Total Potential Sulphate (TPS). Therefore, probably suitable for modification if required following processing and reclassification as General Fill.

Stratum	Proposed end use	Preliminary classification (SHW Series 600)	Comment	Suitability for improvement by the inclusion of binders
Made Ground – Landfill	Unsuitable for reuse on site and should be disposed of at a suitable off-site facility.			
Cornbrash	External areas and below structures	Likely to be Class 1 General Fill or Class 6 Structural Fill	May require processing /crushing to an appropriate grading. Fine fraction probably at or near to Optimum Moisture Content.	Generally low TPS. Therefore, probably suitable for modification if required.
Forest Marble (fine)	External areas and below structures	Likely to be Class 2 General Fill or Class 7 Structural fill.	Likely to be wet of Optimum Moisture Content and moisture conditioning likely to be required.	Unlikely to be suitable due to the high sulfate concentrations.
Forest Marble (rock quality strata)	External areas and below structures	Likely to be a class 1 General Fill or Class 6 Structural fill, following processing.	Will require processing /crushing to reuse.	Unlikely to be suitable due to the high sulfate concentrations.

Where it is proposed to reuse site won materials as an engineered fill it will be necessary to develop an appropriate site-specific Earthworks Specification (EWS). The basis for the Specification should be BS 6031:2009 and the latest version of the SHW, Series 600 Earthworks. The earthworks will also need to be undertaken under a Materials Management Plan (see Section 8.4).

6.4 Foundation recommendations

In accordance with BS EN 1997-1+A1 (2013) (EC7), the proposed commercial distribution buildings are considered to be Geotechnical Category 2. As such, foundation recommendations are presented to aid development proposals only and separate geotechnical design will be required.

The Made Ground (all types) is considered unsuitable in its present condition for use as a founding soil, on the basis of its unpredictable nature and likely deposition in an uncontrolled manner. Therefore, it should either be fully penetrated by all new foundations or replaced with suitably compacted structural fill. The following uses of excavated Made Ground may be acceptable:

- Made Ground – Topsoil – reuse as Landscape Fill below a cover system in areas of soft landscaping.
- Made Ground - excavate, screen, process and re-engineer for reuse as General Fill (below a cover system if used in areas of soft landscaping).

All Made Ground – Landfill, and any Made Ground – Topsoil or Made Ground not reused on site, should be disposed of to a suitable off-site facility and, where required, replaced with suitable 'clean' fill material to create the development platform.

Subject to detailed geotechnical design, the permissible bearing pressures for foundations detailed in this report take into consideration the risk of shear failure of the ground (ultimate limit state). However, they do not assess acceptable limits of settlement (serviceability limit state). Serviceability limit state assessment will need to be undertaken as part of the separate geotechnical design.

6.4.1 Spread foundations

Pad foundations are considered suitable to support the columns for the proposed structures. All foundations should either fully penetrate the unsuitable Made Ground to found at least 300mm into the founding stratum, or be founded in structural fill.

For a pad foundation 1m square a permissible bearing pressure of 110kpa should be available founding in the medium dense or better weathered Cornbrash, a permissible bearing pressure of 250kpa should be available on the very dense weathered Cornbrash or intact rock. Permissible bearing pressures on structural fill will be dependent on the fill materials adopted and the degree of compaction achieved.

Based on the medium volume change potential of some of the soils/weathered rock strata on site, the minimum founding depth for foundations should be at least 300mm below the base of the Made Ground (as noted above) and 0.90m below final ground level, whichever is deeper.

Hydrock has undertaken assessment of founding depth (on natural soils) based on permissible bearing capacities of 110kpa load and 250kPa. These are shown on Hydrock Drawings 27280-HYD-XX-XX-DR-GE-1005 to 27280-HYD-XX-XX-DR-GE-1008. These plans do not take into account the depth influence of trees, or the thicknesses of new fill.

Deepening of foundations in accordance with BRE 240 and BRE 298 will be required where foundations are within the zone of influence of existing, removed or proposed trees and proposed shrub planting. A tree survey should be undertaken by an arboriculturist in accordance with BS 5837:2012 to identify the type, and height of existing trees on the site and including any off-site trees, that could have an effect on foundation design.

If trees are to be removed, the roots should be grubbed out and foundations extended to below the zone of disturbance created by this activity and to below any remaining root hairs.

Where it is not practical to deepen individual pads beyond the influencing distance of trees/desiccated soils, it is recommended that bulk excavation of the affected area be undertaken and, following moisture conditioning, the soils are replaced to an Engineered Specification.

Where foundations are within the zone of potential desiccation from trees and are deeper than 1.5m bgl, a suitable compressible material or void former will be required on the inside faces of foundations to external walls, and beneath piled ring beams and ground bearing floor slabs.

Foundation formations should be inspected by a geotechnical engineer or other suitably competent person to ensure the founding conditions are suitable and as indicated in this report. Any formation materials deemed as unsuitable should be excavated and replaced with lean mix concrete or deepened to suitable strata.

Foundation excavations should be protected from rain, snow, inflow of surface water, frost and freezing conditions. They should also be protected from drying out in hot dry weather.

Any water that collects at the base of the foundation excavations should be removed by pumping from a sump in the base.

6.5 Ground floor slabs

Subject to geotechnical design, following excavation of softer natural soils and Made Ground, and it's replacement with structural fill, placed strictly in accordance with an appropriate Earthworks Specification, ground bearing floor slabs may be adopted. A permissible bearing pressure of 50kN/m^2 should be acceptable. However, this will be dependent on the fill materials adopted and the degree of compaction achieved.

The floor slab should be designed by a structural engineer and a limit state assessment undertaken as part of the geotechnical design.

Prior to the placement of the founding materials and the construction of the ground bearing floor slab, the sub-formation and formation will need to be inspected and checked by a competent person to ensure the ground conditions at time of construction are consistent with the Specification and the design parameters derived from this ground investigation. Testing should be undertaken in accordance with The Concrete Society Technical Report 34 (The Concrete Society 2013) and CD 255. It is recommended that the verification of the sub-formation and formation include, as a minimum, the measurement of Modulus of Subgrade Reaction (k) determined by static plate load testing.

6.6 Roads and pavements

Based on the test results and subject to *in situ* testing during construction, it is considered likely an equilibrium CBR of 3% will be achievable over the majority of the site. However, a CBR of <2.5% should be used for design where Made Ground is left *in situ* beneath proposed roads.

Proof rolling of the formation level will be required and any loose or soft spots should be removed and replaced with an engineered fill, in accordance with a suitable Specification. The formation level will also need to be protected from deterioration during inclement weather; any slopes, including temporary slopes, should be trimmed to falls to shed rain water and the surface sealed to limit infiltration.

Prior to the placement of the founding materials and the construction of the road pavement, the sub-formation and formation will need to be inspected and checked in accordance with a suitable specification to ensure the ground conditions are as expected. All testing should be carried out in accordance with DMRB IAN 73/06 to confirm that the ground conditions at time of construction are consistent with the previous design parameters.

Where the CBR is found to be less than 2.5%, the sub-grade may be unsuitable for both the trafficking of site plant and as support for a permanent foundation, without improvement works being undertaken. Improvement works should be carried out in accordance with CD255. In summary, consideration may be given to the following potential remedial techniques:

- excavation and re-engineering or replacement of weaker soils;
- the inclusion of geosynthetic reinforcement within the unbound layers of the capping and sub-grade;
- where cohesive soils are present and deemed suitable for treatment with hydraulic binders, to employ modification and/or stabilisation techniques on the formation; and
- where granular soils are present, dewatering and re-engineering the formation.

6.7 Drainage

Infiltration tests were undertaken by Ridge (Report 5015203-RDG-XX-ST-DOC-C-00GCA01) during summer months in 6 locations. No infiltration was recorded in three of the locations with Infiltration rates in the other three ranged from 1.6 x 10-5 to 7.75 x 10-5 m/s.

Groundwater level monitoring during summer were recorded between 0.31m bgl and 2.54m bgl with an average GW level of 1.3m across the site historically and during recent investigation work undertaken by Hydrock (monitoring is still ongoing) between 0.30m – 1.21m bgl.

Whilst infiltration rates show that discharge into natural soils may work in some areas of the site in the summer months, the presence of a shallow groundwater table (which is close to surface in winter) show a thin unsaturated zone with the base of any proposed soakaways within the already saturated zone based on the monitoring results. As such based on the data, there is limited available storage capacity to consider drainage via infiltration viable.

In addition, it should be noted that shallow infiltration will only be viable where Made Ground is not present. As Made Ground is present across the site and locally deep where Made Ground – Landfill is present, this should only be considered where Made Ground is removed to prevent the risk of mobilising contaminants within the soils. Furthermore silt/clay from the weathered Cornbrash Formation is present which may limit infiltration at shallow depths.

As such, based on the potential contamination and the shallow groundwater levels, infiltration drainage is not considered suitable.

6.8 Buried concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005) and the information presented in Section 5.5.8 (Table 5.12) the shallow soils (Made Ground, Cornbrash Limestone Formation and Forest Marble Formation) can be classified as Design Sulfate Class DS-1 and ACEC Class AC-1. This equates to a Design Chemical Class[12] of: DC-1.

The designer should check and confirm the classification of concrete using the information presented in Appendix D and Appendix E during the detailed design.

[12] The calculated ACEC class can be used in accordance with BS 8500-1+A2 (2019), Table A.9 to select the Designated Concrete (DC) class for an intended working life of 50 years. However, the designer is referred to BS 8500-1+A2 (2019), for full details and notes to Table A.9, including any Additional Protective Measures (APMs).

7. Geo-environmental assessment

7.1 Updated conceptual model

7.1.1 Updated ground model

The initial CSM developed from the desk study review and field reconnaissance survey (see Section 2) has been updated using the findings of the ground investigation and is presented in Section 5. The updated CSM is the basis for the geo-environmental assessment presented below.

7.1.2 Updated exposure model

Following the ground investigation, the plausible contaminant sources, receptors and pathways identified in the preliminary geo-environmental exposure model Section 3) have been updated or confirmed as follows.

7.1.2.1 Sources

No sources have been removed from, or added to, the exposure model.

7.1.2.2 Receptors

No receptors have been removed from, or added to, the exposure model.

7.1.2.3 Pathways

No pathways have been removed from, or added to, the exposure model.

Using the updated ground model and updated exposure model, generic risk assessment is undertaken as presented below.

7.2 Risk assessment approach

Using the updated CSM, a Tier 2 generic quantitative risk assessment (GQRA) for identified receptors based on all soils sampled has been undertaken in accordance with the principles of LCRM.

Firstly, the risks associated with the identified potential contaminant linkages have been estimated using standardised methods (typically involving comparison of site data with published 'screening values'). Secondly, where screening values are exceeded, the result has been evaluated in an authoritative review of the findings with other pertinent information to determine whether or not the exceedance is or is not acceptable in the site-specific circumstances.

The data sets used in the assessment comprise the analytical results obtained by Hydrock as listed in Section 4, together with any reliable data from previous investigations as listed in Section 2.

In cases where potentially unacceptable risks are indicated and/or the land is potentially unsuitable for its intended use, actions such as more advanced stages of risk assessment (Tier 3, detailed quantitative risk assessment (DQRA)) or remediation are proposed in Section 7.12.

7.3 Human health risk assessment

7.3.1 Soils Assessment

7.3.1.1 Generic Assessment Criteria

The soil screening values used are generic assessment criteria (GAC) (i.e. derived in accordance with EA CLEA guidance (2009) using the updated exposure model detailed in Defra SP1010 (2014), with the exception of published C4SLs. The term 'GAC' used in this report is inclusive of all generic soil screening values.

Based on the proposed development, generic assessment criteria (GAC) based on a default commercial / industrial CLEA land use scenarios have been adopted.

GAC are selected based on the following hierarchy:

- Category 4 Screening Levels (C4SL), where available.
- SoBRA Acute GAC for free cyanide, as acute dose toxicity is the primary risk driver.
- Hydrock GAC, derived by Hydrock as detailed in Appendix G.

The results of the assessment are presented in Appendix G.

7.3.1.2 Data sets

The data sets used in this report are based on the conceptual site model and the proposed development, and are summarised as:

- Made Ground - Topsoil across the site
- Made Ground – Landfill – in the centre of the site
- Made Ground – underlying the Made Ground – Topsoil, and outside the interpreted Landfill area
- Natural soils

GAC based on a soil organic matter (SOM) of 2.5% for Made Ground, Made Ground - Landfill and natural soils and 6% for Made Ground - Topsoil based on laboratory analysis results. Assessment sheets are presented in Appendix G

7.3.1.3 Assessment Results

The individual analytical results have been compared with the relevant GAC. Based on individual test results that exceed the GAC, the chemicals of potential concern (CoPC) which require further assessment are summarised in Table 7.1. The presence of these CoPc exceedances requires further consideration.

Table 7.1: CoPC in soils which require further assessment (human health)

CoPC	GAC (mg/kg)	GAC Source	No. samples	Min. (mg/kg)	Max. (mg/kg)	No. samples >GAC
Made Ground – Topsoil						
Benzo(b)fluoranthene	45	Hydrock GAC	10	0.05	64.4	1
Dibenz(a)anthracene	3.6		10	0.05	4.87	1

CoPC	GAC (mg/kg)	GAC Source	No. samples	Min. (mg/kg)	Max. (mg/kg)	No. samples >GAC
Made Ground – Landfill						
Lead	2,300	C4SL – CL:AIRE 2014	10	19	16,200	1
Made Ground						
Benzo(b)fluoranthene	45	Hydrock GAC	6	0.05	67.5	1
Dibenz(a)anthracene	3.6		6	0.05	3.93	1

The recorded concentrations of petroleum hydrocarbons (PHCs), SVOCs and VOCs in all samples submitted for analysis are below the relevant GAC.

The phrase 'further assessment required' is used to denote soil concentrations that exceed a GAC. This does not necessarily mean that the soil is 'contaminated' or not otherwise suitable for use. The assessment and any mitigation required are to ensure the site does not pose an 'unacceptable risk' as defined under Planning and Part 2A of EPA 1990.

7.3.2 Asbestos

Asbestos Containing Materials were not encountered during the historical investigations but were noted in the Made Ground - Topsoil in WS108 during Hydrock's ground investigation works. This material was identified in the laboratory as chrysotile asbestos cement. In addition, asbestos fibres have been identified by laboratory testing of soil samples during both the Ridge and Hydrock investigations as summarised in Table 7.2

Table 7.2: Asbestos in soil samples (laboratory testing)

Location	**Stratum**	Depth (m bgl)	% Asbestos (w/w)	Comment
TP01	Made Ground – Landfill	0.90	0.002	Fibre bundles – chrysotile
TP02	Made Ground – Landfill	0.20	<0.001	Fibre bundles – chrysotile
WS04	Made Ground - Landfill	0.40	0.003	Fibre bundles – amosite
WS05	Made Ground - Landfill	0.50	0.010	Fibre bundles – chrysotile
WS06	Made Ground – Topsoil	0.40	<0.001	Fibre bundles – chrysotile
WS07	Made Ground – Topsoil	0.20	0.929	Chrysotile cement

The presence of Asbestos Containing Materials and asbestos fibres in soil requires further consideration.

7.3.3 Risk evaluation

The screening exercise has identified asbestos, lead, benzo(b)fluoranthene and dibenz(a)anthracene at concentrations above the GAC. These are considered further here to assess if the exceedance may be acceptable with respect to the proposed development. The phrase 'further assessment' does not necessarily mean that the soil is 'contaminated' or not fit for use.

7.3.3.1 *Benzo(b)fluoranthene and dibenz(a)anthracene in Made Ground - Topsoil*

Benzo(b)fluoranthene at a concentration of 64.4mg/kg compared to a GAC of 45mg/kg and dibenz(a) anthracene at a concentration of 4.87mg/kg compared to a GAC of 3.6mg/kg, have been identified in the Made Ground – Topsoil. Whilst these exceedances are slight, some mitigation is recommended. However, the mitigation of risk to human health from asbestos is the driving force on the site and mitigation measures for that purpose will serve to mitigate the risk from these PAH species.

7.3.3.2 *Benzo(b)fluoranthene and dibenz(a)anthracene in Made Ground*

Benzo(b)fluoranthene at a concentration of 67.5mg/kg compared to a GAC of 45mg/kg and dibenz(a) anthracene at a concentration of 3.93mg/kg compared to a GAC of 3.6mg/kg have been identified in the Made Ground. Whilst these exceedances are slight, some mitigation is recommended. However, the mitigation of risk to human health with regards to asbestos is the driving force on the site and mitigation measures for these will serve to mitigate these risks.

7.3.3.3 *Lead in the Made Ground - Landfill*

Lead is recorded in the Made Ground – Landfill at a concentration of 16,200mg/kg compared to a GAC of 2,300mg/kg. This significant exceedance is considered to be an unacceptable risk, which requires mitigation for the proposed end use. However, the mitigation of risk to human health with regards to asbestos is the driving force on the site and mitigation measures for these will serve to mitigate these risks.

7.3.3.4 *Asbestos*

Whilst Asbestos Containing Materials (asbestos cement - chrysotile) were only encountered in one location, asbestos fibres (between <0.001% v/v and 0.01% v/v of chrysotile and amosite) have been detected in Made Ground – Topsoil in three locations in the south and east of the site and in Made Ground – Landfill in two locations. No asbestos has been recorded in the area of the former Rifle Range in the west of the site and north of the proposed building areas

Hydrock consider it plausible for asbestos to be present in Made Ground soils in the south and east of the site and asbestos, even at low concentrations, represents an unacceptable risk to human health and mitigation measures will be required in all areas of the site.

7.4 Phytotoxicity risk assessment

7.4.1 *Risk estimation*

Priority phytotoxic chemical concentrations have been screened against published values to determine the likely risk to plant growth (phytotoxic GAC). Phytotoxic GAC based on a pH of >7% have been adopted for all soils based on laboratory results.

As with human health, individual sample test results are compared directly with the phytotoxic GAC.Based on individual test results that exceed the phytotoxic GAC, CoPC which require further assessment are summarised in Table 7.3.

Table 7.3: CoPC which require further assessment (phytotoxic)

CoPC	GAC (mg/kg)	Basis for GAC	No. samples	Min. (mg/kg)	Max. (mg/kg)	No. samples >GAC
Made Ground - Topsoil						
Copper	200	BS3882:2015	10	14	600	2
Zinc	300		10	66	1,500	4

CoPC	GAC (mg/kg)	Basis for GAC	No. samples	Min. (mg/kg)	Max. (mg/kg)	No. samples >GAC
Made Ground - Landfill						
Copper	200	BS3882:2015	10	16	517	2
Zinc	300		10	35	1,200	2

7.4.2 Risk evaluation

Detriment to plant life is difficult to quantify and many of the GAC are based on agricultural crop yields rather than harm to particular plant species.

Recorded concentrations of copper in the Made Ground – Topsoil and Made Ground - Landfill are locally slightly elevated when compared to the GAC. Recorded concentrations of zinc are locally significantly elevated compared to the GAC. However, the vegetation on site did not show any signs of physical distress.

Notwithstanding the concentrations of contaminants identified, the mitigation of risk to human health (as discussed in Section 7.3.3) will also serve to mitigate risks to plant life (by the placement of a suitable 'clean' growing medium) where mitigation measures are required

7.5 Pollution of controlled waters risk assessment

7.5.1 Summary of historical results.

Historical groundwater sampling as part of the Ridge ground investigation recorded no exceedances of the screening criteria with regards to tested determinants (heavy metals, PAH petroleum hydrocarbons, BTEX and MTBE) and therefore the risk to controlled water was considered to be low. As a result, Hydrock has not undertaken any additional sampling or assessment as part of its works .

7.6 Coal Tar in bituminous material

7.6.1 Laboratory testing

Laboratory chemical testing confirmed concentrations of benzo(a)pyrene above 50mg/kg, a key indicator of the presence of coal tar (as defined in the guidance note produced by the Association of Directors of Environment, Economy Planning and Transport (ADEPT) entitled 'Managing Reclaimed Asphalt – Highways and Pavements', ref. 2019-1, dated August 2019) in one sample (A1) recovered from the asphalt/tarmac covered track/road in the east of the site, as summarised in Table 7.4).

Table 7.4: Coal Tar laboratory testing

Core Reference	Core Location Reference	Laboratory Sample Reference	Depth of layer tested (mm bgl)	Concentration of benzo(a)pyrene (mg/kg)
A1	Track east	A1	Surface	86
A2	Car park	C2	Surface	4.5

7.6.2 Summary

The results of the laboratory testing on the core samples indicate that coal tar-based binders have been used in the construction of at least some roads on the site.

7.7 Ground gases risk assessment

7.7.1 Data

As per BS8576:2013 'Decision Matrix for Initial Monitoring', it is judged from the available evidence that the gas generation potential at the site is low, based on the fact that the site is predominantly underlain by natural soils with an area of what is understood to be inert, landfill. In accordance with Tables 5.5a and 5.5b of CIRIA C665, the sensitivity of the proposed development is low due it being a commercial end use Consequently, and in accordance with CIRIA C665 (Table 5.5a and 5.5b) and Figure 6 of BS8576:2013, an appropriate minimum monitoring regime is six readings over two months, provided other monitoring requirements are also met, such as prevailing atmospheric pressure conditions (for example, BS 8485:2015 +A1:2019 and CL:AIRE TB17 advocate that monitoring should include a period of rapidly falling atmospheric pressure).

Hydrock have undertaken six monitoring rounds with a furthur six undertaken historically by Ridge . This has, included monitoring during periods of falling and low atmospheric pressure. As such, the conclusions presented below are considered to approximate to worst-case conditions pending completion of the monitoring and review of the results.

7.7.2 Assessment

The risks associated with the ground gases methane (CH_4) and carbon dioxide (CO_2) have been assessed using BS 8485:2015 +A1:2019,

The assessment guidelines set out in Table 2 of BS 8485 are based on interpretation of the gas concentrations and the gas flow rates. The quantitative assessment has been carried out by comparing the individual gas concentrations and gas screening values (GSV[13]) in Appendix D with the published CS thresholds (BS 8485 Table 2), in addition to a worst-case GSV assessment in accordance with section 6.3.7 of BS 8485. In addition, a ternary plot assessment of the data (assessment of ground gas ratios: O_2 + N_2, CO_2 and CH_4) has been undertaken in general accordance with guidance by Wilson et. al. (2018). The ternary plot assessment is presented in Appendix F. The full assessment is also presented in Appendix F, and is summarised in Table 7.5.

Table 7.5: Ground gas risk assessment

	Min	Max	Typical	Comment
Steady Flow Rate (l/hr)	-0.1	0.1	<1	-
Methane (%)	0.1	0.1	<1	The typical methane concentration is less than 1% and the typical carbon dioxide concentration is less than 5%.
Carbon Dioxide (%)	0.1	4.9	<5	
Carbon Monoxide (ppm)	1	2	-	-
Hydrogen Sulphide (ppm)	1	1	-	-
Oxygen (%)	9.2	22.1	18	-
Carbon Dioxide GSV (l/hr)	<0.07	<0.07	<0.07	CS1
Methane GSV (l/hr)	<0.07	<0.07	<0.07	CS1
Plausible worst-case check	-	0.01	-	CS1

[13] Note: GSV is synonymous with 'site characteristic hazardous gas flow rate' (Q_{hgs}) of BS 8485:2015 +A1:2019 Table.

As indicated in Table 7.5, the computed GSV for carbon dioxide and methane indicates CS1 conditions and methane and carbon dioxide at concentrations are 'typically' below 1% and 5% respectively. As such, the site is provisionally classified as Characteristic Situation 1.

7.8 Construction materials risk assessment

7.8.1 Water pipelines

A formal water pipe investigation and risk assessment is beyond the scope of this report. However, the findings of this investigation have been compared to the threshold values in Water UK HBF (2014), Table 1 as far as is practicable.

The site is predominantly previously undeveloped, with a small area of a former landfill known as the 'old dump' brownfield (former landfill) in the north-west corner. Assessment has indicated no exceedance of the threshold values in the 'old dump' but some locally in the Made Ground across other areas of the site at shallow depths (generally <0.50m bgl).

Subject to agreement with the local water supply company, it may be possible for the site to be classified as non-contaminated from the perspective of the water supply pipe requirements, with standard pipework for pipes placed in natural soils.

Alternatively, it may be necessary to prepare separate water pipe risk assessments on a plot-by-plot basis in order to demonstrate to the water supply company the suitability of standard polyethylene pipework in areas where exceedances are not recorded; otherwise barrier pipe may be required in at least some areas of the site.

7.8.2 Other construction materials

Plastic pipes for drains and sewers are manufactured from unplasticized poly vinyl chloride (PVC-U), polypropylene (PP) or polyethylene (PE). These materials may be affected by the presence of organic compounds in the soil.

In accordance with the British Plastics Federation Guidance (August, 2018), as the concentrations of PAH and or BTEX are, at least locally, above 100mg/kg and the concentrations of petroleum hydrocarbons (TPH) are, at least locally, above 200 mg/kg, the pipework manufacturer should be consulted with regard the suitability of plastic pipework.

The implications for buried concrete are discussed in Section 6.8.

7.9 Contamination risks to ground workers

7.9.1 Introduction

Whilst risks to construction workers are not discussed in detail, the following section discusses potential risks that should be considered.

Information presented in this document is provided to assist in managing the risk associated with contamination in soil and groundwater at the site but is not definitive. The Contractors are responsible for undertaking their own assessments and assessing what risks are present and what control measures are required.

Task specific risk assessments and method statements should be in place, and risks and required mitigation measures communicated to all relevant personnel prior to the works commencing. Appropriate PPE and, if required, RPE should be provided and utilised.

7.9.2 Metals, metalloids, PAH and petroleum hydrocarbons

The soils locally contain elevated concentrations of petroleum hydrocarbons, PAH and lead, which may pose a risk to site construction and/or below-ground maintenance workers.

7.9.3 Ground Gas

It is noted that concentrations of carbon dioxide (an asphyxiant) in the soil exceed HSE Workplace Exposure Limits for personnel in the working environment of 1.5% for short term (15 minutes) exposure and 0.5% for long term exposure. Furthermore, soil concentrations of oxygen are below the HSE recommendations of 18%.

Soil gas concentrations are not necessarily reflected by those in the breathing zone, as such, all Contractors and maintenance workers should be made aware of the possible presence of carbon dioxide and should take all necessary health and safety precautions when working in trenches or confined spaces.

7.9.4 Asbestos

Occasional visible fragments of suspected asbestos cement sheeting have been identified during the ground investigation and low concentrations of asbestos fibre (up to 0.01%) have been identified during the laboratory testing of soils.

All site staff should be made aware that there is a likelihood of encountering further asbestos containing materials within the Made Ground anywhere on the site, and at any stage of the development. It is advised that the Contractor should supply suitable and sufficient 'Asbestos Awareness' training (specific to asbestos in soils) to all site staff who could foreseeably encounter asbestos containing materials during the course of their work.

The Contractor for each stage of works must undertake a suitable and sufficient Risk Assessment in accordance the Regulation 6 of the Control of Asbestos Regulations 2012 (CAR2012). The results of the assessment should be used to compile a methodology in accordance with Regulation 7 of CAR2012, which limits potential exposure and spread of asbestos fibre. Appropriate training should be provided to all site staff identified within the risk assessment as having the potential to be exposed or encounter asbestos during their work in accordance with Regulation 10 of CAR2012.

It is the responsibility of the Contractor to ensure that mitigation measures are suitable and sufficient to prevent exposure to airborne asbestos so far as is reasonably practicable in accordance with Regulation 11 of CAR2012.

It is recommended that any asbestos cement sheeting encountered is handpicked under controlled conditions in accordance with HSG210 'Asbestos Essentials' Hand picking needs to be undertaken by suitably qualified Contractors in accordance with HSE guidance and an Environmental Permit. All ACM must be suitably packaged, placed in a dedicated, covered and lockable skip pending off-site disposal to a suitably licensed waste facility.

In addition to the presence of Occasional/Random / Sporadic/Random visible fragments of suspected asbestos cement sheeting, the soils contain low concentrations of asbestos fibre (<0.001%). The Contractors for each stage of works must manage the risks in accordance with HSE Guidance and CAR 2012. However, the asbestos fibres detected at the site are within a soil matrix, and if this is kept damp, this should assist in minimising the risk of the release of airborne fibres.

7.10 Findings of the generic contamination risk assessments

The potential sources, pathways and receptors identified in the desk study (Section 2) have been investigated (Section 4 and 5)and assessed (Sections 7.2 to 7.8). A Source-Pathway-Receptor linkage assessment has been undertaken and is presented in Appendix J (Table J.2).

A summary of the Source-Pathway-Receptor (SPR) contaminant linkages for which the risks may be unacceptable and require mitigation (those that are moderate or higher) are discussed in Table 7.6.

Table 7.6: Residual risks following risk evaluation

Contaminant Linkage				Comments	
Pollutant Linkage	Sources	Pathways	Receptors	General	Mitigation
PL 1	PAH in the Made Ground - Topsoil and Made Ground. Lead in the Made Ground - Landfill	Ingestion inhalation or direct contact	Human health	There is Made Ground below the entire site and Made Ground – Landfill in the north-west.	Mitigation required in the form of an engineered cover system for soft landscaped areas in the south and east of the site.
PL 2	Asbestos fibres and Asbestos-Containing Materials (ACM) in the Made Ground	Inhalation of fugitive dust.	Human health.	ACM recorded in Made Ground. Asbestos fibres recorded in soil samples.	Mitigation required in the form of an engineered cover system in the south and east of the site. In addition, any ACM encountered during site development will need to be handpicked and removed from site.
PL 3	Copper and zinc in the Made Ground – Topsoil and Made Ground – Landfill.	Root uptake.	Plant life.	Significant (zinc) or slight (copper) exceedance of the GAC.	'Clean' growing medium will be required as part of the engineered cover system where placed.
PL 4	Coal tar in tarmac track in east of the site.	Ingestion, inhalation or direct contact.	Human health.	Presence of coal tar indicated in one pavement core.	Mitigation required in the form of excavation and off-site disposal, with verification of removal
PL 5	PAH, BTEX and TPH in Made Ground – Topsoil.	Direct contact	Water supply pipes.	The Made Ground – Topsoil contains PAH, BTEX and petroleum hydrocarbons at concentrations in excess of the acceptable levels.	Installation of 'Protectaline' (or similar) pipework may be needed locally at least.

7.11 Climate change

In considering the potential impact of climate change, the following factors have been taken into account:

- The design life of the proposed development is 50 years.
- The location and elevation of the site in relation to projected increased flooding extents is outside of likely flooding events.
- The current depth to groundwater is shallow and likely to be variable due to seasonal events.
- The soils below the site are likely to be physically adversely affected by desiccation.
- The UK Climate Predictions published by the Met Office indicate that over the lifetime of the proposed development average:
  - Precipitation is forecast to increase during winter months and decrease during summer months.
  - Temperature is forecast to increase by a worst case scenario of 6 to 7 degrees.
  - Groundwater recharge is forecast to increase by 0.8mm per day.
- Potential changes in soil moisture levels and soil temperature may have a significant impact on contaminant fate and transport (mobility and degradation) noting that a rise in soil temperature will likely increase the volatility and solubility of contaminants and increase the microbial degradation of contaminants. A reduction in soil moisture may decrease microbial degradation and increase vapour and gas diffusion.

Based on a review of the above scenarios, no foreseeable impacts of climate change on the CSM have been identified. For further details on the considerations made, refer to Table K1 in Appendix K.

7.12 Mitigation measures

As shown in Table 7.6 (and subject to regulatory approval) Hydrock considers the following mitigation is required to ensure the site is suitable for the proposed end use:

- Break out of all hardstanding and below ground obstructions and (where appropriate) processing for reuse in accordance with a suitable specification and a Materials Management Plan (MMP) (PL4).
- Reuse or disposal of existing road surfacing materials (Coal Tarr – PL4)
- Appropriate materials handling and stockpiling in accordance with the Materials Management Plan (MMP) to ensure soils that contain asbestos fibres are reused beneath hardstanding, a cover system or disposed of off-site.
- The installation of a 300mm engineered cover system in soft landscaped areas (excluding the former rifle range areas and the remaining soft standing north of the proposed buildings) comprising a bonded geogrid/geotextile break layer (e.g. TX160G), overlain by subsoil, beneath a topsoil growing medium at least 100mm thick (PL1 - PL3), with deepening of the cover system where required to account for trees and shrub planting..
- Import of subsoil and topsoil in accordance with the Materials Management Plan (MMP) for use in the earthworks and to create an engineered cover system (PL1 - 3) where required;
- Installation of Protectaline pipework if required (PL5).

The methodology for the remediation should be set out in a 'Remediation Strategy' (which will include the 'Implementation Plan', the 'Verification Plan' and the 'Long Term Monitoring and Maintenance Plan'), which will need to be submitted to the warranty provider and the regulatory authorities for approval.

In addition, the production of a Materials Management Plan and its approval by a Qualified Person will be required to allow import of material to, and reuse of suitable material at, the site in accordance with the Waste Management Regulations.

8. Waste and materials management

8.1 Introduction

The Waste Framework Directive (WFD) (2009/98/EC) defines waste as "*any substance which the holder discards or intends to discard".* In a geo-environmental context, the waste is most often 'soil' and the two main scenarios are off-site disposal of the material as a waste and reuse of the material on site. For cost and sustainability reasons, reuse is preferred to off-site disposal.

Section 8.2 below describes the key issues relating to off-site disposal to landfill, and Section 8.4 considers requirements relating to reuse of soils and materials management.

8.2 Waste disposal

8.2.1 Principles

Based on the WFD, any material excavated on site may be classified as waste and it is the responsibility of the producer of a material to determine whether or not it is waste. Where off-site disposal is undertaken, the following guidance applies.

Classification is a staged process:

- A hazardous waste is defined under the WFD as one which possesses one or more of fifteen defined hazardous properties. If a waste is not defined as hazardous, then it is non-hazardous.
- Where the materials are soil, it is then be assigned using the 'List of Waste Codes', which classifies the material as either:
  - hazardous (17-05-03), which is defined as "*soil and stones containing hazardous substances*"; or
  - non-hazardous (17-05-04), which is defined as "*soil and stones other than those mentioned in 17-05-03*".
  - Hydrock utilise the proprietary assessment tool, HazWasteOnline™ to undertake this assessment.
- Waste Acceptance Criteria (WAC) testing is then undertaken if required, and are only applicable following classification of the waste, and only where the waste is destined for disposal to landfill. The WAC are both qualitative and quantitative. The WAC and the associated laboratory analyses (leaching tests) are not suitable for use in the determination of whether a waste is hazardous or non-hazardous.

It should be noted that some non-hazardous wastes may be suitable for disposal at an inert landfill as non-hazardous waste, subject to meeting the appropriate waste acceptance criteria.

It should be noted that classification must be undertaken on the waste produced, by the waste producer. Necessary sampling frequency to adequately characterise a soil population is defined within WM3.

Further discussion with regards to the characterisation process for different scenarios and waste types is provided below.

8.2.2 HazWasteOnline™ assessment

As the site is brownfield, in order to inform the preliminary waste characterisation process, Hydrock has undertaken an exercise using the proprietary web-based tool HazWasteOnline™. The output of the HazWasteOnline™ assessment is provided in Appendix H and a summary of the preliminary waste classification is provided below in Section 8.2.4.

8.2.3 WAC testing

The site is brownfield and the qualitative WAC tests are provided in Appendix G a summary of the preliminary waste disposal options is provided below in Section 8.2.4.

8.2.4 Preliminary waste disposal options

The site is brownfield and based on the site history, WAC testing, the historical CAT-Waste testing and the HazWasteOnline™ assessment, if suitable segregation of different types of waste is put in place, for soils to be disposed of, it is considered that:

- The Made Ground -Topsoil, which generally has a low organic content (as proven by the Loss on Ignition and Total Organic Carbon tests) is likely to be classified as non-hazardous waste for disposal at a non-hazardous landfill, although one sample (WS12 @ 0.05m bgl) is noted as hazardous due to the presence of visible ACM.
- Made Ground – Landfill is likely to be classified as hazardous because of the recorded concentrations of lead and zinc in three samples (WS04 @ 0.40m, WS05 @ 0.50m and TP103 @ 0.10m).
- Made Ground is likely to be classified as non-hazardous waste for disposal at a non-hazardous landfill.
- The natural uncontaminated soils are likely to be classified as non-hazardous waste and should be able to be disposed of at an inert landfill.
- Any soils containing >0.1% asbestos or visible asbestos containing materials would be considered as hazardous.
- The screening and testing undertaken on the bituminous bound pavement have proven concentrations of benzo(a)pyrene of >50mg/kg which is an indicator that coal tars are present above hazardous waste limits (0.1%), and as such will likely be classified as hazardous waste.

8.2.5 General waste comments

It should be noted that:

- It is the waste producer's responsibility to segregate the waste at source and waste producers must not mix waste materials/streams or dilute hazardous components, for example by mixing with less or non-hazardous waste on site to meet WAC limit values.
- The above preliminary assessment has been made on the basis of the soils tested as part of the ground investigation, using WAC testing and the HazWasteOnline™ assessment. However, the formal classification of waste can only be undertaken on the material to be disposed of, and by the waste producer and the receiving landfill as license conditions vary from landfill to landfill.
- Basic Characterisation should be undertaken in accordance with Environment Agency guidance by the waste producer. Hydrock can assist if required and this report will assist the characterisation. However, Basic Characterisation does not form part of the current commission and would require further assessment and testing on the wastes actually to be disposed.
- Once the waste producer has undertaken an initial Basic Characterisation on each waste stream, they can manage the soils as part of the on-site processing programme (for example, stockpiling, treatment, screening and separation). The waste producer and landfill operator will then need to agree the suite of compliance testing for regularly generated waste to demonstrate compliance with the initial Basic Characterisation prior to disposal.
- At the time of disposal, additional testing on the excavated soils to be disposed of, will likely be necessary.
- Non-hazardous and hazardous soils require pre-treatment (separation, sorting and screening) prior to disposal.

- The costs for disposal of non-hazardous and hazardous soils are significant compared to disposal of inert material.
- In addition to disposal costs, landfill tax will be applicable. Non-hazardous and hazardous waste will generally be subject to the Standard Rate Landfill Tax. Inert or inactive waste will generally be subject to the Lower Rate Landfill Tax. The landfill tax value changes each April and can be found at https://www.gov.uk/government/publications/rates-and-allowances-landfill-tax/landfill-tax-rates-from-1-april-2013.
- Before a waste producer can move waste to a landfill site for disposal, they need to check the landfill site has the appropriate permit and must have completed the following[14]:
  - Duty of care transfer note / Hazardous Waste consignment note, including comment as to if pre-treatment has been undertaken; and
  - Basic Characterisation of the waste, to include: description of the waste; waste code (using list of wastes); composition of the waste (by testing, if necessary) and; WAC testing (if required).

8.3 Reuse of bituminous bound pavement waste containing coal tar

The Ridge site investigation proved that some of the bituminous bound pavement materials contains coal tar (otherwise known as, Asphalt Waste Containing Coal Tar (AWCCT)).

If AWCCT is to be re-used on site, it will need to be re-used in accordance with the Environment Agency Regulator Position Statement 075 (EARPS075).

In order to comply with EA RPS075 allowing the re-use of AWCCT in construction operations for hard paving structures, without an environmental permit, the contractor needs to comply with the following items presented in the statement:

"We will not pursue an application for an environmental permit for the use of where:

- The treated AWCCT meets the requirements of clause 948, ex-situ cold recycled bound material, within the Specification for Highways Works Series 900, or clauses 810 to 880 for cement and other hydraulically bound mixtures within the Specification for Highway Works Series 800.
- The material is used only in bound sub-surface layers e.g. sub-base, base and binder layers. Use in surface applications is not allowed.
- You meet the relevant objectives of the Waste Framework Directive;
  - *'... ensuring that waste management is carried out without endangering human health, without harming the environment and in particular: (i) without risk to water, air, soil, plants or animals; (ii) without causing a nuisance through noise or odours; and (iii) without adversely affecting the countryside or places of special interest.'"*

The material containing coal tar will need to be placed as part of hardstanding (but cannot be placed below buildings and cannot be placed at the surface), which will break the pathway between the material and the end users of the site. However, it is recommended that the location of the coal tar containing material is recorded in the Health and Safety file to ensure future maintenance workers are aware of the potential risks. The location of the coal tar containing materials should be surveyed in and presented on a plan in the contractor's validation report.

A Controlled Waters Detailed Quantitative Risk Assessment (DQRA) will be required to derive the site-specific remediation target values and comply with the EA regulations. The DQRA should take into account: the transport in the unsaturated zone; dilution upon entering the aquifer; and

[14] Environment Agency. November 2010. 'Guidance on waste acceptance procedures and criteria. Waste acceptance at landfills'.

attenuation within the aquifer pathway. Based on our experience with DQRA and PAH contamination, Hydrock would generally expect such a DQRA to rule out any risk to Controlled Waters primarily based on the travel times of the PAH species. However, the only way this can be proven is by completing the DQRA.

Bench trial testing is likely to be required in order to satisfy the Environment Agency and comply with the Remediation Strategy and Verification Plan. It should be noted that bench trial testing can take a significant period of time and if required, it is recommended this is undertaken early.

8.4 Materials management

Soils that are to remain on site, should be managed and reused in accordance with a Materials Management Plan (MMP), prepared in accordance with 'The Definition of Waste: Development Industry Code of Practice', Version 2 (CL:AIRE), known as the DoWCoP. Where all aspects of the DoWCoP are followed the soils are considered not to be waste, because they were never discarded in the first place.

Landfill Made Ground soils cannot be re-used under the DoWCoP.

Version 2 of the DoWCoP clearly sets out the principles and an outline of the requirements of a MMP. The following compliance criteria must be seen to apply to the MMP for the site:

Factor 1: Protection of human health and protection of the environment.

Factor 2: Suitability for use, without further treatment.

Factor 3: Certainty of Use.

Factor 4: Fixed Quantity of Material.

The reuse of soils at sites should be considered during the planning and development design process so that compliance with issues such as fixed quantity and certainty of use clearly relate to agreed site levels. Suitability of Use is normally evident from the remediation strategy or the design statement, which form an integral part of a MMP. However, some soils may need to be tested post-excavation to prove they are suitable for use.

Once the MMP is finalised, it must be declared by a Qualified Person (QP). The Declaration is an on-line submission as part of which the QP is required to confirm that the declaration is being made before the relevant works have commenced (i.e. it is not a retrospective application).

Once all material movements have been completed in accordance with the MMP a verification report must be produced, kept for 2 years and provided to the EA on request.

It should be noted that failure to comply with the requirements of the DoWCoP when re-using materials has potentially significant consequences for the waste holder. The risk is that the reused materials are still regarded as a waste that has been illegally deposited. From 1 April 2018, the scope of Landfill Tax has been extended to sites operating without the appropriate environmental disposal permit, and operators of illegal waste sites will now be liable for Landfill Tax. Further information is available at: https://www.gov.uk/government/publications/landfill-tax-disposals-not-made-at-landfill-sites/landfill-tax-disposals-not-made-at-landfill-sites.

If soils are excavated and reused on sites (or moved to another site) without a MMP, exemption, or appropriate Permit in place, anyone who knowingly facilitates the disposal may be *'jointly and severally liable'* to any assessment of tax, fines or prosecution.

9. Uncertainties and limitations

9.1 General comments

Hydrock Consultants Limited (Hydrock) has prepared this report in accordance with the instructions of Bicester Motion (the Client), under the Client's instructions to proceed (PO BM01090) under the terms of appointment for Hydrock, for the sole and specific use of the Client and parties commissioned by them to undertake work where reliance is placed on this report. Any third parties who use the information contained herein do so at their own risk. Hydrock shall not be responsible for any use of the report or its contents for any purpose other than that for which it was prepared or for use of the report by any parties not defined in Hydrock's appointment.

This report details the findings of work carried out in October and November 2023. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, not all potential environmental constraints or liabilities associated with the site may have been revealed.

Hydrock has used reasonable skill, care and diligence in the design of the investigation of the site and in its interpretation of the information obtained. The inherent variation of ground conditions allows only definition of the actual conditions at the locations and depths of trial pits and boreholes at the time of the investigation. At intermediate locations, conditions can only be inferred.

Groundwater data are only representative of the dates on which they were obtained and both levels and quality may vary.

Plans that provide assessment of foundation types and depths are indicative and subject to further design. This design should incorporate a detailed assessment of the influence of trees, influence of cut to fill proposals and geological conditions.

Unless otherwise stated, the recommendations in this report assume that ground levels will remain as existing. If there is to be any re-profiling (e.g. to create development platforms or for flood alleviation) then the recommendations may not apply.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness.

Where the existing report(s) prepared by others have been provided by the Client, it is assumed that these have been either commissioned by the Client, or can be assigned to the Client, and can be relied upon by Hydrock. Should this not be the case Hydrock should be informed immediately as additional work may be required. Hydrock is not responsible for any factual errors or omissions in the supplied data, or for the opinions and recommendations of others. It is possible that the conditions described may have since changed through natural processes or later activities.

The work has been carried out in general accordance with recognised best practice. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance. Where the phrase 'suitable for use' is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment Agency Technical Guidance WM3, they are not primarily intended for that purpose and additional analysis will be required at the time of disposal to fully classify waste. Discussion and comment with regards to waste classification are preliminary and do not form the requirements of 'Basic Characterisation' as required.

Assessment and testing for the presence of coal tar has only been completed at the locations of exploratory holes undertaken for risk assessment purposes. This investigation is not designed to provide a definitive assessment of the risk from coal tar, nor the waste classification for bituminous bound pavement arisings at the site.

Unless otherwise stated, at the time of this investigation the future routes of water supply pipes had not been established. This investigation and sampling strategy may not be fully compliant with UKWIR recommendations. Consequently, a targeted investigation and specific sampling and chemical testing may be required at a later date once the routes of the supply pipes are known. In addition, it is recommended that the relevant water supply company be contacted at an early stage to confirm its requirements for assessment, which may not necessarily be the same as those recommended by UKWIR.

Whilst the preliminary risk assessment process has identified potential risks to construction workers, consideration of occupational health and safety issues is beyond the scope of this report.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds, this report does not constitute a formal survey of these potential constraints and specialist advice should be sought.

Any site boundary line depicted on plans does not imply legal ownership of land.

10. Recommendations for further work

Following the ground investigation works undertaken to date, the following further works will be required:

- discussion and agreement with utility providers regarding the materials suitable for pipework;
- discussions with regulatory bodies and, if applicable, the warranty provider regarding the conclusions of this report;
- assessment of tree influence on foundations and design of foundations;
- provision of geotechnical design for the Category 2 (earthworks, floor slabs, foundations etc.);
- production of a Remediation Strategy and Verification Plan (and agreement with the regulatory bodies and the warranty provider);
- production of a Materials Management Plan relating to reuse of soils at the site and import of soils to the site;
- remediation and mitigation works; and
- verification of the earthworks, remediation and mitigation works.

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Appendix A Drawings

Notes

Do not scale from this drawing.

All dimensions are to be checked prior to construction and any discrepancies are to be identified to the Architect.

N

Area schedule	SQM	SQFT
B1 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B2 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B3 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B4 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B5 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B6 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B7 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B8 GROUND FLOOR & 1ST FLOOR	2,800	30,138
B9 GROUND FLOOR & 1ST FLOOR	5,600	60,277
Total	**28,000**	**301,381**
Total park spaces	**359**	

Revisions

Scale	Size	Date	Drawn	Checked
1 : 1000	A1	25/04/23	TF	SB

Client
Bicester Motion Limited

Project
Bicester Motion
Innovation Quarter

Title
Proposed site plan phase 2

Purpose
For Information

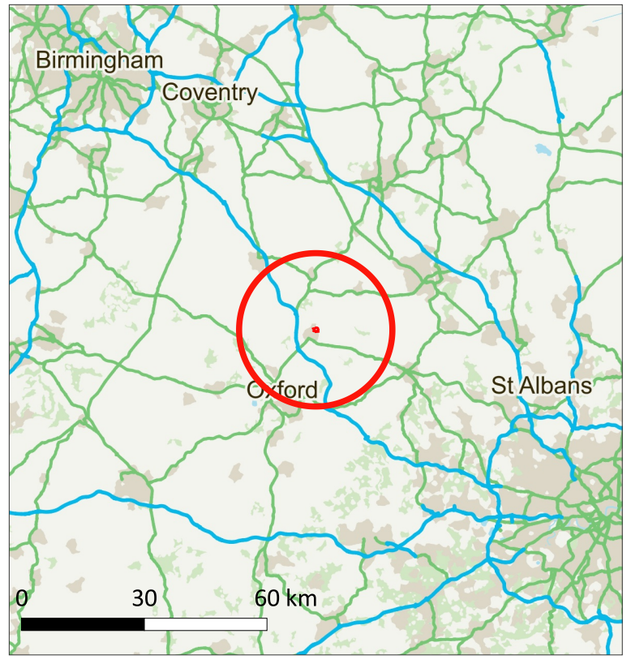
Status Code
S1

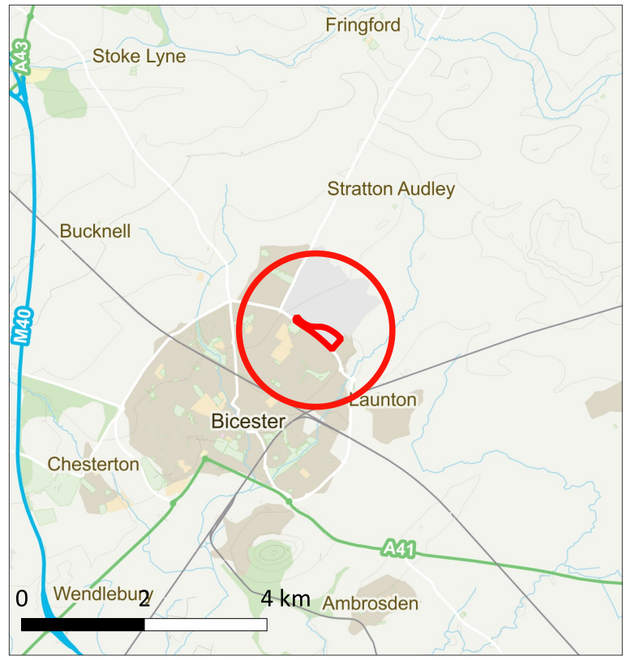
3DReid
www.3DReid.com
Architecture Interiors Masterplanning

Drawing No.
220127-3DR-ZZ-00-DR-A-07008

Rev.

Time Stamp: 26/04/2023 15:58:53





KEY PLAN

Site Boundary

NOTES

1. Contains OS data © Crown copyright and database right (2022)

REVISIONS

REV.	DRAWN BY INITIALS	CHECKED BY INITIALS	DATE	REVISION NOTES/COMMENTS
P01	AT	NT	20/11/23	First issue

Hydrock

TITLE
SITE LOCATION PLAN

HYDROCK PROJECT NO.
27280

SCALE @ A3
1:5,000

CLIENT
Bicester Motion

PURPOSE OF ISSUE
SUITABLE FOR INFORMATION

STATUS
S2

PROJECT
Bicester Motion Innovation Quarter

DRAWING NO.
27280-HYD-XX-XX-DR-GE-1000

REVISION
P01

KEY

- Site Boundary (approximate)
- WS### Hydrock Dynamic Sampler Borehole
- TP### Hydrock Trial Pit
- ## Superficial Samples

Previous SI: Ridge Property & Construction Consultants (2021)

- BH## Rotary Borehole
- WS## Dynamic Sampler Borehole
- TP## Trial Pit
- SA## Soakaway Pit

Previous SI: LQA SI(2003)

- Trial Pit
- Borehole

Previous SI: LQA SI(2007)

- Trial Pit
- Borehole

NOTES

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.

2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

3. This drawing has been based on the following drawings and information: Ridge Property & Construction Consultants Topographical Survey No: 25557Q-1 Dated: August 2021.
Indicative Layout Plan. Number: 220127-3DR-22-00-DR-A-08003. Dated: 01/06/23.

REV.						
P02	SECOND ISSUE					
	RT	23/10/23	NT	23/10/23	JC	23/10/23
P01	FIRST ISSUE					
	SD	02/08/23	NT	02/08/23	JC	02/08/23
	REVISION NOTES/COMMENTS					
	DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

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CLIENT

Bicester Motion Ltd

PROJECT

Bicester Motion Innovation Quarter

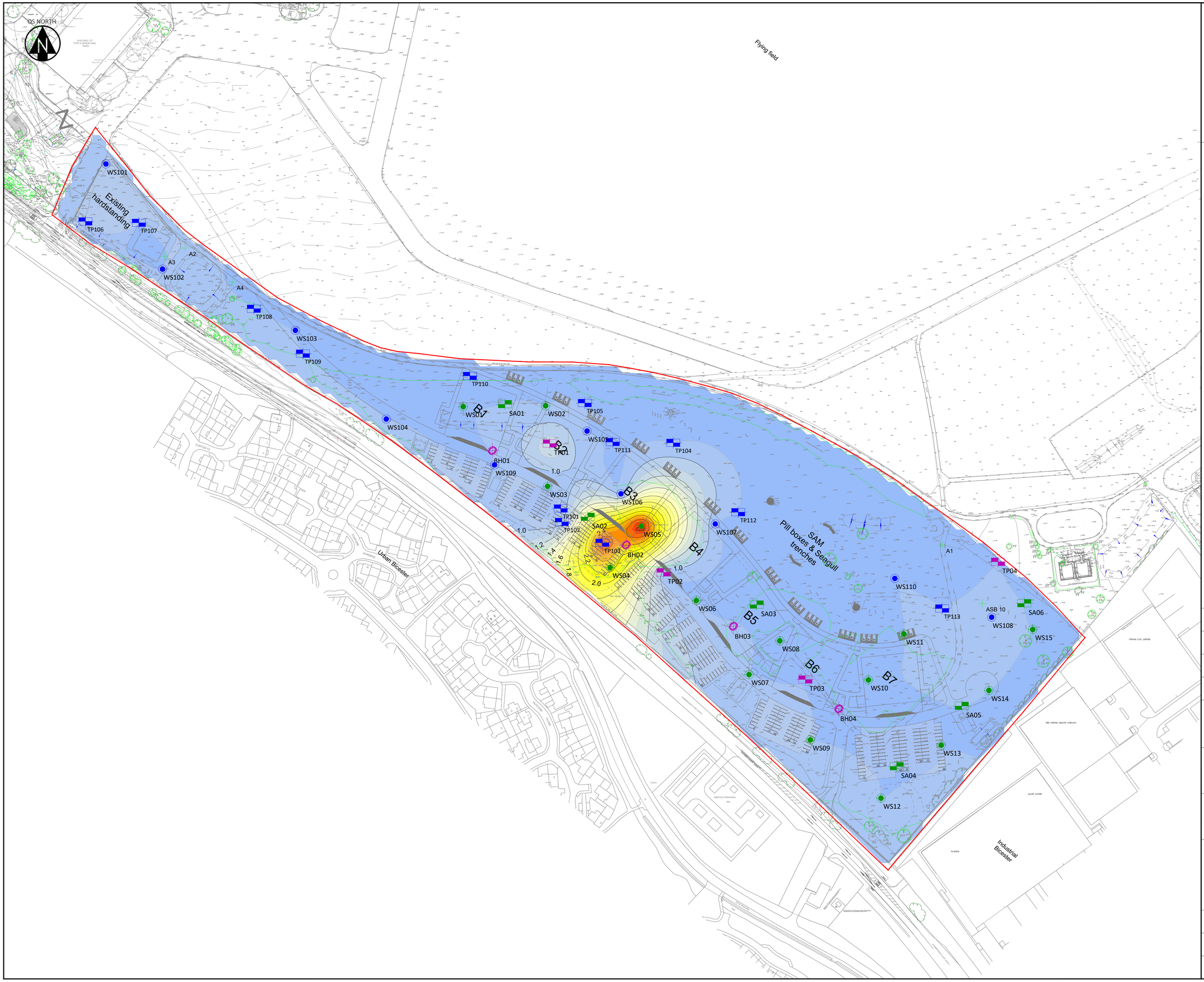
TITLE

Exploratory Hole Location Plan

HYDROCK PROJECT NO.	SCALE @ A1
27280	1:1250

PURPOSE OF ISSUE	STATUS
SUITABLE FOR INFORMATION	S2

DRAWING NO. (PROJECT CODE-ORGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER)	REVISION
27280-HYD-XX-XX-DR-GE-1002	P02



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Indicative Layout Plan. Number: 220127-3DR-22-00-DR-A-08003. Dated: 01/06/23.

4. Based on Ridge Ground Condition Assessment report - Reference 5015203-RDG-XX-ST-DOC-C-00GCA01.

5. Subject to confirmation following Hydrock Site Investigation.

REV.	REVISION NOTES/COMMENTS					
	DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
P03	THIRD ISSUE					
	RT	01/11/23	NT	01/11/23	AB	01/11/23
P02	SECOND ISSUE					
	RT	26/10/23	NT	26/10/23	AB	26/10/23
P01	FIRST ISSUE					
	RT	26/09/23	NT	26/09/23	AB	26/09/23

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CLIENT

Bicester Motion Ltd

PROJECT

Bicester Motion Innovation Quarter

TITLE

Foundation Depth (mbgl)
110kPa

HYDROCK PROJECT NO.	SCALE @ A1
27280	1:1250

PURPOSE OF ISSUE	STATUS
SUITABLE FOR INFORMATION	S2

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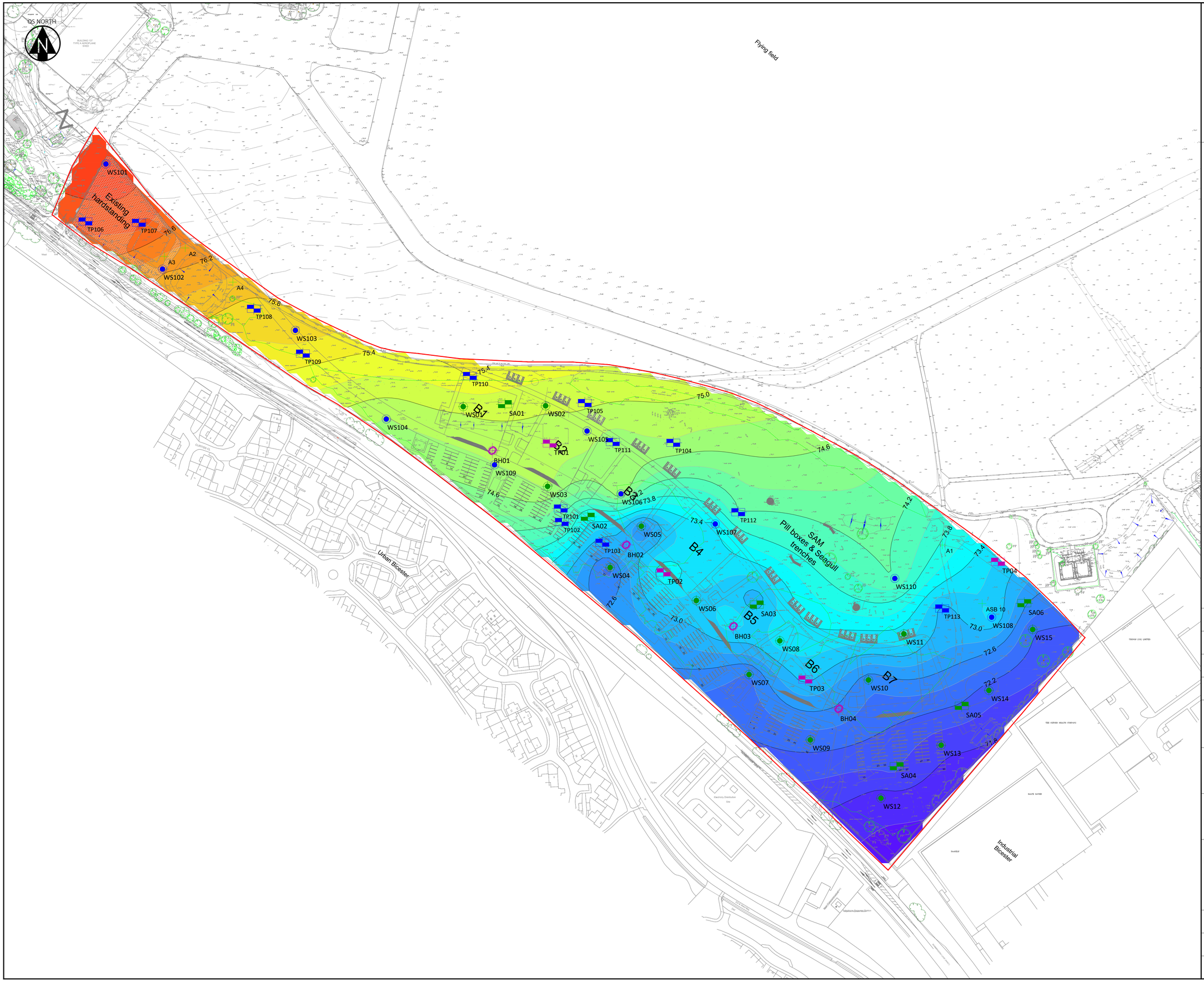
27280-HYD-XX-XX-DR-GE-1003	P03



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5. Subject to confirmation following Hydrock Site Investigation.

Level mOD

- 77.0
- 76.6
- 76.2
- 75.8
- 75.4
- 75.0
- 74.6
- 74.2
- 73.8
- 73.4
- 73.0
- 72.6
- 72.2
- 71.8
- 71.4

P03	THIRD ISSUE					
	RT	01/11/23	NT	01/11/23	AB	01/11/23
P02	SECOND ISSUE					
	RT	26/10/23	NT	26/10/23	AB	26/10/23
P01	FIRST ISSUE					
	RT	28/09/23	NT	28/09/23	AB	28/09/23
REV.	REVISION NOTES/COMMENTS					
	DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

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CLIENT

Bicester Motion Ltd

PROJECT

Bicester Motion Innovation Quarter

TITLE

Foundation Level (mOD)
110kPa

HYDROCK PROJECT NO.	SCALE @ A1
27280	1:1250

PURPOSE OF ISSUE	STATUS
SUITABLE FOR INFORMATION	S2

DRAWING NO. (PROJECT CODE-ORGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER)	REVISION
27280-HYD-XX-XX-DR-GE-1004	P03