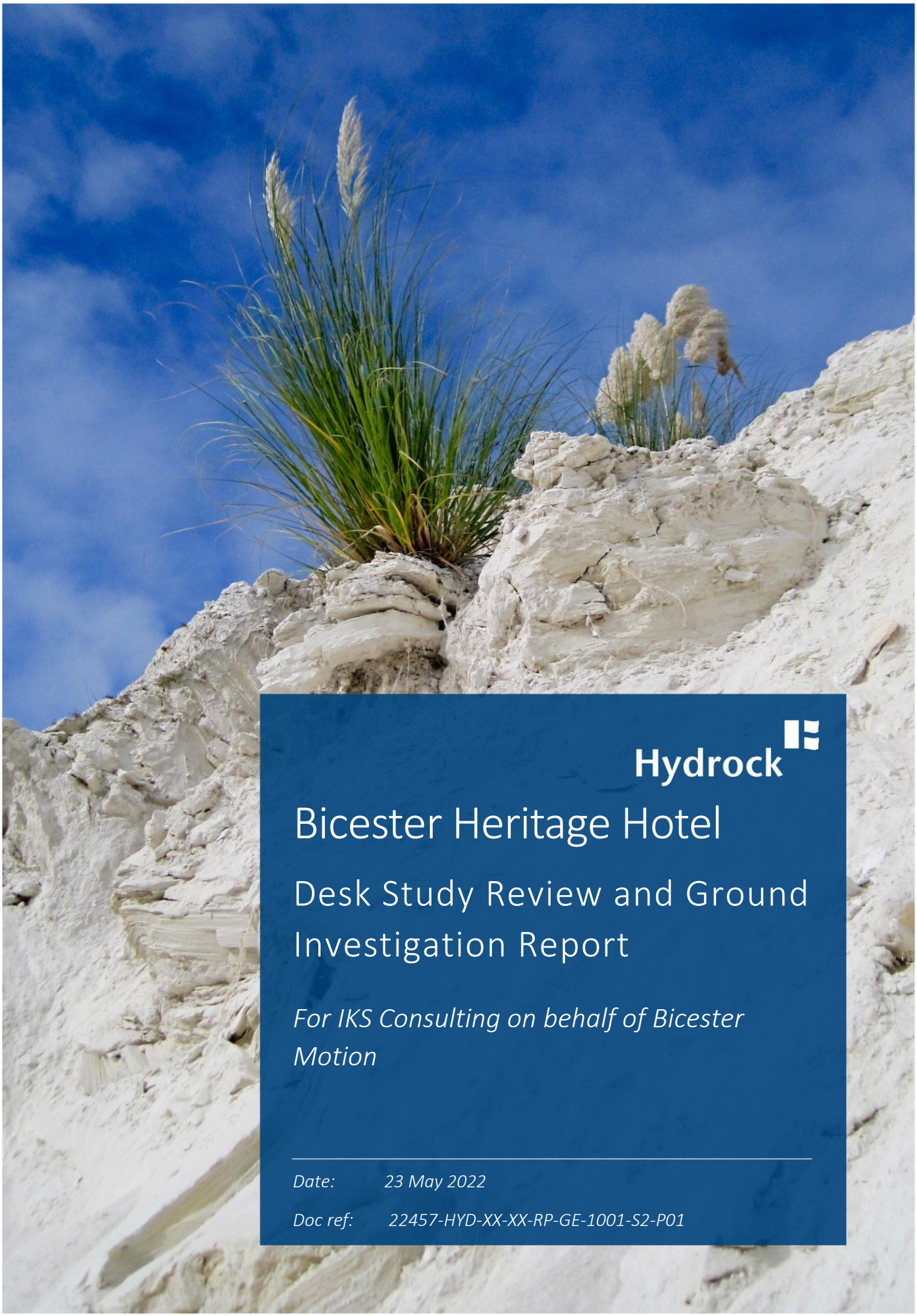

Hydrock

Bicester Heritage Hotel

Desk Study Review and Ground Investigation Report

For IKS Consulting on behalf of Bicester Motion

Date: *23 May 2022*

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Client	IKS Consulting on behalf of Bicester Motion.
Site name and location	Bicester Heritage Hotel. The site is located approximately 1.5km north of Bicester and the nearest postcode is OX27 8AL. The site is approximately 4 hectares in area and is located immediately east of Buckingham Road (A4421), within the former Bicester Aerodrome which forms part of the former RAF Bicester site.
Proposed development	The site development proposals are understood to comprise a four-storey hotel with associated parking, access roads and infrastructure.
GROUND MODEL	
Desk study summary	The site currently comprises grassland and former macadam taxi-ways with notable features including an aviation fuel line with associated inspection chambers in the south-west, in the south a control box and small electricity sub-station and in the west is an RAF bunker interpreted to be the foundation of a former anti-aircraft gun as described in the client provided archaeological report (Appendix D). Review of historical Ordnance Survey mapping indicates: • Prior to 1918, the site and surrounding area was predominantly agricultural land adjacent to the Roman Way to the west, with a minor quarry to the south-east of the site, and another to the north (which is the site of the present-day Stratton Audley Quarry). Hungerford Farm and Brashford Farm are located to the north while South Farm is towards the south-east of the site. • From 1918, the wider site was occupied by the Royal Flying Corps which became the Royal Air Force (RAF) in 1928. After demolition of the original buildings, the airfield was used as a logistical centre and training facility by the RAF in World War 2 and thereafter for storage, maintenance, repair and salvage of aircraft and equipment until 1976. • The United States Air Force (USAF) reopened the facility in 1978 and it operated as a base until 1994. • The airfield continued to be used by the RAF until 2004 since then the site has remained active. • Former airfield taxiways, adjacent to the eastern boundary of the site, are currently used for events for the wider site. The geology at the site consists of Cornbrash Formation overlying the Forest Marble Formation with no natural superficial deposits. Localised Made Ground is likely to be present. Solution features are potentially present in the limestone. The Cornbrash Formation comprises a Secondary A aquifer. The site is not located within a Source Protection Zone and there are 3 groundwater abstractions within 1km of the site.

	The site is in Flood Zone 1 (with a low probability of flooding from rivers or the sea). There are historical limestone quarries and there is a possibility of unrecorded workings within the site. There are no waste management sites recorded within 250m of the site. There are no significantly elevated naturally occurring elements to pose a contamination risk. The specialist UXO risk assessment indicates a medium risk and recommends a detailed UXO threat assessment desk top study to be undertaken for the site.
Ground and groundwater conditions encountered by investigation	The ground conditions as proven by the investigation undertaken at the site comprise: • Topsoil – between 0.00m and 0.20m below ground level (bgl) and comprised a mixture of brown slightly sandy slightly gravelly clay and slightly clayey sand with frequent rootlets and gravel sized fragments of flint and limestone. • Made Ground – between 0.15m and >0.90m below ground level (bgl), comprising a mixture of brown and orangish brown slightly sandy slightly gravelly clay, clayey sandy gravel and clayey gravelly sand with gravel sized fragments of brick, asphalt and concrete. • Cornbrash Formation – from 0.15m to at least 3.00m bgl, comprising shelly limestone with various degrees of weathering (not proven below 3m but likely to extend to 4-5m bgl according to BGS sources available online). Groundwater was encountered at approximately 1.80m bgl during the investigation. Water levels recorded post-fieldwork ranged from 1.35m bgl to 1.84m bgl (80.8m OD to 81.2m OD).
GEOTECHNICAL CONCLUSIONS	
Conclusions of geotechnical assessment	Obstructions should be anticipated associated with the former RAF buildings, including foundations, services and infrastructure, together with strong limestone at shallow depth. Excavation to proposed founding depth should feasible with standard excavation plant. Heavy duty excavation plant/breaking equipment may be required to excavate the Cornbrash Formation and existing obstructions. Excavations during investigation were generally stable. Water seepages into excavations may not be adequately controlled by sump pumping and alternative methods of dewatering may be required. Depending on the structural details of the proposed buildings, foundations are provisionally recommended to comprise shallow spread (pad or strip) foundations. an initial permissible bearing pressure of 200 kPa is recommended. Foundations should extend to below the Made Ground to a competent horizon in the Cornbrash. A minimum foundation depth of 900mm below final ground level should be allowed for, subject to detailed design. A design CBR of 5% is likely to be achievable over the majority of the site. A CBR of <2.5% should be used for the Made Ground. Soakaway drainage is considered suitable for this site. However, soakaways are recommended to be kept at least 5m from existing and proposed buildings and structures to reduce risk of subsidence caused by dissolution of the limestone. Buried concrete - Design Sulfate Class - DS-1 and ACEC Class AC-1.
GEO-ENVIRONMENTAL CONCLUSIONS	
Conclusions of contamination Generic risk assessment	Human health: • No elevated concentrations of contaminants of potential concern (COPC), when compared to Generic Acceptance Criteria (GAC). Plant growth: • No elevated concentrations of COPC, when compared to the GAC. Controlled Waters: • Whilst there are exceedances of the water quality targets, these exceedances are considered not to represent a significant risk of pollution of Controlled Waters from an on-

	site source as there is no evidence of artificial accumulations of these substances on the site. Ground gases or vapours: • Medium risk from ground gases based on the recording of carbon monoxide and CS2 conditions apply. Gas mitigation measures to provide 2.5 points in accordance with BS 8485 are recommended. Radon: • The site is not in a Radon Affected Area. Buried pipe construction materials: • PVC-U, PP or PE pipework is considered suitable for drains. Water supply pipes: • Standard pipework is envisaged suitable for buried potable water supply pipes, subject to confirmation from the water supply company.
Proposed contamination mitigation measures	Gas mitigation measures in accordance with CS2 conditions are required.
Waste management	The 'General' Made Ground is likely to be classified as 'Non-hazardous waste' based on the HazWasteOnline™ assessment. WAC testing in this Made Ground indicates a waste classification of 'Inert Waste Landfill'.
FUTURE CONSIDERATIONS	
Further work	Following the ground investigation works undertaken to date, the following further works will be required: • discussions with regulatory bodies and others regarding the conclusions of this report; • assessment of tree influence with regard to planting proposals on foundations and design of foundations as part of the geotechnical design; • provision of geotechnical design for the Category 2 structure (earthworks, retaining, floor slabs, foundations etc.); • discussion and agreement with utility providers regarding the materials suitable for pipework; • production of a Materials Management Strategy and Materials Management Plan relating to reuse of soils at the site and import of soils to the site; • production of a Remediation Strategy and Verification Plan (and agreement with the regulatory bodies and the warranty provider); • remediation and mitigation works; and • verification of the remediation and mitigation works.

This Executive Summary forms part of Hydrock Consultants Limited report number Reference. and should not be used as a separate document.

1. INTRODUCTION

1.1 Terms of reference

In February 2022, Hydrock Consultants Limited (Hydrock) was commissioned by IKS Consulting on behalf of Bicester Motion (the Client) to undertake site investigation, comprising a Phase 1 desk study and Phase 2 ground investigation at Bicester heritage site, A4421, Launton, Bicester OX26 5HA.

The site is part of a former RAF airfield and currently consists of grassland and former macadam taxi-ways with a few relicts of its former use.

Hydrock understands that the proposed development is to comprise a four-storey hotel with associated parking, access roads and infrastructure. A proposed development layout (Anthony Stiff Associates drawing reference ASA-548-SK-808), is presented in Appendix D.

The works have been undertaken in accordance with Hydrock's proposal referenced (C22457-HYD-XX-XX-FP-GE-1001-P2 16/12/21) and the Client's instructions to proceed (e-mail dated 24th January 2022).

1.2 Objectives

The site investigation has been commissioned to support the discharge of planning conditions and to assist with the design of the development.

The site investigation includes review of a Phase 1 Desk Study previously carried out by others (see Section 1.4) and a Phase 2 Ground Investigation. The objective of the Phase 1 Desk Study was to formulate a preliminary Ground Model and an Initial Conceptual Model of the site to identify and make a preliminary assessment of key geo-environmental and geotechnical risks to the proposed development.

The objectives of the Phase 2 Ground Investigation are:

- to resolve uncertainties identified in the Phase 1 Desk Study by refining and updating the preliminary Ground Model, determining geo-environmental and geotechnical site conditions and identifying key contamination risks by updating and finalising the Conceptual Model in accordance with the principles of LCRM;
- to identify geo-environmental mitigation requirements to enable development; and
- to provide preliminary geotechnical recommendations for design.

1.3 Scope

The Phase 1 Desk Study undertaken by Crestwood Environmental Ltd (Appendix D) comprised:

- a field reconnaissance (walkover) to determine the nature of the site and its surroundings including current and former land uses, topography and hydrology;
- acquisition and review of:
  - » historical Ordnance Survey maps, to identify former potentially contaminative uses shown at the site and immediately surrounding it, and an assessment of the associated contamination risks;
  - » a third-party environmental report to identify flooding warning areas, local landfills, pollution incidents, abstractions, environmental permits etc. which may have had the potential to have environmental impact on the site;

  - » topographical, geological and hydrogeological maps;
  - » British Geological Survey (BGS) archive records;
- development of a preliminary Ground Model representing ground conditions at the site;
- development of an outline Conceptual Model (oCM), including identification of potential pollution linkages;
- a qualitative assessment of any geo-environmental risks identified; and

Hydrock has acquired updated environmental desk study data (Appendix D) and has undertaken a separate site reconnaissance. The results are included in the desk study review in Section 2.

The scope of the Phase 2 Ground Investigation comprises:

- A ground investigation including trial pitting and rotary drilling to:
  - » obtain data on the soil and rock ground and groundwater conditions of the site;
  - » allow collection of samples for geotechnical and chemical laboratory analysis;
  - » allow geotechnical field tests to be undertaken; and
  - » install gas and groundwater wells;
- gas concentration and groundwater level monitoring;
- groundwater sampling;
- 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 plausible pollution linkages;
- completion of a generic quantitative risk assessment of potential chemical contaminants to establish 'suitability for use' under the current planning regime;
- discussion of 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 IKS Consulting on behalf of Bicester Motion for use in the preparation of this report:

- Crestwood Environmental Ltd. for Bicester Heritage Centre, 6th July 2018. 'Phase 1 Land Contamination and Ground Condition Report. In support of a Planning Application for the Development of a Hotel at Bicester Heritage Centre, Buckingham Road, Bicester, Oxfordshire OX27 8AL', Ref: CE-BI-1363-RP02-Final.
- Anthony Stiff Associates. 19th June 2018. 'Bicester Heritage Hotel - Site Layout', Ref: ASA-548-SK-808.

- Oxford Archaeology, for Bicester Heritage. 20th January 2018. 'Proposed Hotel Development, Bicester Heritage, Buckingham Road, Bicester', Ref: BIHHDBA.
- Groundsure. Undated. 'Preliminary Unexploded Ordnance Threat Assessment'. Ref: 502858.
- Unattributed. Undated. 'Scan of services survey of the site area', Unreferenced.

The above documents have been referred to for information purposes and as they are understood to have been commissioned by, or assigned to the Client, Hydrock has placed full reliance on them. However, if this is not the case, Hydrock should be informed immediately.

The provided desk study (Crestwood Environmental Ltd. 6th July 2018) is included in Appendix D and the content is summarised in Section 2. This content has been used to formulate 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 2.15.

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, 'Land Contamination: Risk Management' (LCRM, 2019) and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

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

Phase 2 comprises intrusive ground investigation work and testing. The factual information from Phase 1 and Phase 2 are used to develop the Conceptual Model (CM). This CM is based on a ground model of the site physical conditions and an exposure model of the possible contaminant linkages. The CM 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 NHBC Standards (2022), have also been referred to.

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) and 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. PHASE 1 STUDY (DESK STUDY REVIEW AND FIELD RECONNAISSANCE)

2.1 Introduction

Hydrock has been provided with a Desk Study for the site prepared by Crestwood Environmental Ltd (as detailed in Section 1), and this is provided in Appendix D. Hydrock has acquired updated environmental and historical desk study data not included in the Crestwood report. Hydrock generally agrees with the findings of the Desk Study. The following section is a summary of the pertinent information presented in the Desk Study, supplemented by additional information as required.

Hydrock has undertaken an updated field reconnaissance survey on 14th February 2022 to visually assess potential geotechnical hazards, contaminant sources, pathways and receptors and to ensure the site conditions as reported in the desk study are still current.

The weather during the updated field reconnaissance survey was sunny with intermittent rain and strong winds.

2.2 Site location

The site is located approximately 1.5km north of Bicester and the nearest postcode is OX27 8AL. The site is centred on National Grid Reference SP 59237 24739.

2.3 Site description

The site is located within Bicester Airfield, formerly RAF Bicester. It is irregular in shape and approximately 4 hectares in area with a gently sloping and flat topography. The site slopes down gently to the south. The surrounding topography is generally raised to the west and to the east, it slopes down approximately 6 metres towards Langford Brook.

The site is bounded by the A4421 to the west, a number of buildings with associated infrastructure to the south and Bicester Airfield to the north and east.

Across the site the surface covering comprises grassland and former macadam taxi-ways in the south west.

Visible features of note include:

- an aviation fuel line with associated inspection chambers and inspection covers in the south west,
- a control box and small electricity sub-station in the south; and
- an RAF bunker in the west, interpreted to be the foundation of a former anti-aircraft gun as described in the Archaeological Report (Appendix D).

Access to the site was via a gated entrance off the A4421 to the north of the site area.

2.4 Site history

- For information on the site prior to the late 19th century, reference should be made to the archaeological report (Appendix D);
- Prior to 1918, the site and surrounding area were predominantly agricultural land adjacent to the Roman Way to the west, with a minor quarry to the south-east of the site, and another to the north (which is the site of the present-day Stratton Audley Quarry). Hungerford Farm and Brashfield Farm are located to the north while South Farm is towards the south-east of the site.

- From 1918, the wider site was occupied by the Royal Flying Corps, -the fore-runner of the Royal Air Force (RAF). According to the archaeological report (Appendix D) from 1918 to 1922 the site comprised three trussed roof training depot stations, a doping workshop and associated infrastructure. After 1928 the buildings at site were used as a logistical centre and training facility by the RAF.
- In World War 2 and thereafter, it was used for storage, maintenance, repair and salvage of aircraft and equipment until 1976, when RAF Bicester ceased being an active station.
- The United States Air Force (USAF) reopened the facility in 1978 and it operated as a USAF base until 1994, after which it continued to be used by the RAF until 2004. From 2004 until 2021, the airfield remained active.
- Former airfield taxiways, adjacent to the eastern boundary of the site, are currently used as a for events for the wider site.

Specifically on the site, there was a series of hangers along the western part of the site dating from the early part of the 20th Century, with associated buildings located on the western side of the site. These were demolished in 1920 and the flying field reverted back to agricultural land, but in 1933 the WW2 airfield was built. By the latter part of the 20th Century, the site was similar to its current configuration, with macadam taxi-ways present in the south and off site to the east. There was an aviation fuel installation / 'bunker' in the central west of the site which comprised an earth bund surrounding a fuel tank. The archaeological report (Appendix D) indicates that this fuel tank and bund has since been removed however, the taxiways are still present.

There is a Scheduled Monument (RAF Bicester: World War 2 Airfield (OA 29)) on the site which comprises part of the brick-built base of an historical anti-aircraft gun position and munition store, located to the north-west of the former fuel tank and bund.

2.5 Geology

The British Geological Survey Maps (BGS) indicates the solid geology of the area to be Cornbrash Formation comprising bioclastic limestone with interbeds of mudstone overlying the Forest Marble Formation, which comprises interbedded limestone and mudstone.

There are no natural superficial deposits or drift geology recorded overlying the Cornbrash Formation. However, Made Ground is expected to be locally present across the site resulting from its historical use.

2.6 Hydrogeology

The Environment Agency classifies the Cornbrash Formation as a Secondary A aquifer - permeable layers capable of supporting water supplies at a local rather than strategic scale, in some cases forming an important source of base flow to rivers.

The site is not located above a groundwater Source Protection Zone (SPZ) or within the 500m buffer zone of an SPZ.

The nearest recorded licensed groundwater abstraction is located approximately 350m north of the site, for domestic use.

2.7 Hydrology

Reference to the Environment Agency web site shows the site is located within the catchment of the Cherwell, Thame and Wye with the specific river water body being the Langford Brook (source to downstream A41). The current (2019 cycle 2) overall status under the Water Framework Directive is 'good'.

The river Ray, located 7km South West of the site - flowing South West, also falls within the catchment of the Cherwell, Thame and Wye, as well as the River Cherwell, located 10km west of the site - flowing South. The current (2019 cycle 2) overall status under the Water Framework Directive for both rivers is 'good'. These rivers are both eventual receptors of surface run off from the site as it is located in-between and at a higher topographic level to the two rivers (OS Map).

The main resource of groundwater supplying the base flow to rivers in the vicinity of the site is the limestone of the Cornbrash Formation.

The nearest site surface water feature is a spring, located to the south of the site boundary. The Langford Brook is located to the East of the site, which flows north-east to south-west direction, in addition there is a tributary to the Langford Brook, the Audley Brook, located East of the site and at its closest point to the site (approximately 0.5km away) flows from south-east to north-west.

2.8 Flood risk

The desk study information 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

There are no coal mining areas or brine affected areas within 75m of the site and no non-coal mining areas within 50m of the site. There are no records of any geological disturbances and no evidence of recent coal mining that will affect the proposed development.

A former limestone quarry previously named Stratton Audley Quarry is indicated approximately 400m north-east of the site. There are also a number of former quarries recorded within 750m on the historical maps (Appendix D). Therefore, it is possible that unrecorded workings may be present under the site, given its indicated geology.

2.10 Waste management

There are no waste management sites recorded within 250m of the site.

Table 2-1: Waste exemptions within 250m of the site

Regulatory Data	Distance from Site	Details	Potential Risk	Comment
Current Waste Exemptions	135m West	Taylor Wimpey Site. Use of waste in construction.	No	Due to small volume of waste and distance from the site
	234m South	LNT Construction Site. Use of waste in construction.	No	Due to small volume of waste and distance from the site

2.11 Regulatory information

Information in the GroundSure Report (Appendix D), relating to various regulatory controls has been reviewed, with a summary presented in Table 2-2.

Table 2-2: Regulatory information within 500m of the site

Regulatory Data	Distance from Site	Details	Potential Risk	Comment
Trade Directory Entries	58m S	Vintage Tyres. Vehicle Parts and Accessories.	No	Due to being down gradient of the site.
	96m SW	Tank. Tanks (Generic).	No	Due to being down gradient of the site.
	103m S	Electricity Sub Stations. Electrical Features.	No	Due to being down gradient of the site.
	107m SW	Numerous entries including; Vehicle Repair, Testing and Servicing, Aviation Engineers, Container and Storage.	No	Due to being down gradient of the site.
	113m NW	Electricity Sub Station. Electrical Features.	No	Due to distance from site.
	114m S	Legends Automotive Limited. Vehicle Repair, Testing and Servicing	No	Due to being down gradient of the site.
	115m S	Bicester Heritage. Vehicle Repair, Testing and Servicing.	No	Due to being down gradient of the site.
	117m SW	2507 Bicester Squadron Air Training Corps. Armed Services.	No	Due to being down gradient of the site.
	124m S	Classic performance Engineering Limited. Vehicle Repair, Testing and Servicing.	No	Due to being down gradient of the site.
	127m N	Supaclean Chemicals Ltd. Colours, Chemicals and Water Softeners and Supplies.	Yes	Due to being up gradient of the site.
	151m W	Electricity Sub Station. Electrical Features.	No	Due to distance from site.
	206m SW	Numerous entries including; Vehicle Repair, Testing and	No	Due to being down gradient of the site.

Regulatory Data	Distance from Site	Details	Potential Risk	Comment
		Servicing, Vehicle Components.		
	209m NW	Tony Wilkins Plastering. General Construction Supplies.	No	Due to limited contamination potential.
	236m NW	Electricity Sub Station. Electrical Features.	No	Due to distance from the site.
Licensed Discharges to controlled waters.	362m North	Sewage discharges-Final treated effluent discharged to the Cornbrash Strata. Active from 1981-present.	Yes	Due to being up gradient from the site.
Historical Tanks	32m E	Unspecified Tank. Date 1990.	No	Due to being down gradient of the site.
	35m E	Unspecified Tank. Date 1966 and 1994.	No	Due to being down gradient of the site.
	85m SW	Unspecified Tank. Date 1966, 1990 and 1994.	No	Due to being down gradient of the site.
	311m SE	Unspecified Tank. Date 1990.	No	Due to being down gradient of the site and distance from the site.

2.12 Natural soil chemistry

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

2.13 Radon

The radon risk is reported in the previous desk study mentioned in Section 1 indicates that the site is not in a Radon Affected Area and radon protection measures are not required for new buildings at the site.

2.14 Unexploded ordnance (UXO)

The previous desk study indicates a generally low risk of UXO from WW2 bombing. However, the former RAF airfield is likely to have been a target for Luftwaffe bombing therefore further assessment is required with regard to UXO. A specialist UXO risk assessment is recommended and has been undertaken by Hydrock (See Appendix D).

The specialist UXO risk assessment (Dynasafe BACTEC Limited and FIND Mapping Limited, Reference: 502858), indicates a medium risk and further action is required with regard to UXO.

Table 2-3: Non-specialist UXO screening (for the purposes of ground investigation)

Data	Comment	Further Assessment Required
Site History	From 1918, the wider site was occupied by the Royal Flying Corps and then by the Royal Air Force (RAF). In 1928 it was used as a logistical centre and training facility by the RAF in World War 2. Thereafter it was used for storage, maintenance, repair and salvage of aircraft and equipment until 1976, when RAF Bicester ceased being an active	Yes

Data	Comment	Further Assessment Required
	station. The United States Air Force (USAF) reopened the facility in 1978 and it operated as a USAF base until 1994, after which it continued to be used by the RAF until 2004.	
Post War Development	The 1920's OS map shows buildings adjacent along the western perimeter of the site. In the 1938 OS map these buildings are no longer shown either for security reasons or because they had been demolished. The 1950's OS map also shows no buildings but the site area is now labelled 'airfield' and the mapping is likely to be restricted for security reasons. The 1960's OS map to present day shows the same depiction of buildings around the site area although the airfield shifted further east.	Yes
Geology Type	As the ground conditions comprise limestone of the Cornbrash Formation, over the Forest Marble Formation, with no superficial deposits or drift geology recorded, it is unlikely UXO would remain undetected. However, due to the historical military usage of the site, there is the potential that undetected UXO is present on site.	Yes
Surface Cover during WWI	The surface cover during WW2 comprised open fields. There is the potential that UXO, if present, would remain undetected.	Yes
Indicator of Aerial Delivered UXO	Screening against the regional bomb risk map Appendix D indicates the site to be in an area where the bomb risk is moderate.	Yes

2.15 Reliability of previous data

Data from the previous ground investigation reports listed in Section 1 have been considered during the preparation of this report. The section below provides comment as to the applicability of the various data available.

2.15.1 Geological data

The geological data from previous investigation are consistent with the anticipated ground conditions from BGS sources and have been utilised in this report.

3. OUTLINE CONCEPTUAL MODEL

3.1 Introduction

The outline Conceptual Model (oCM) incorporates evidence from the site walkover, the Desk Study and previous reports and investigations relating to the site to establish potential pollutant linkages with unacceptable risks to the receptors associated with the proposed development. The formulation of an outline Conceptual Model is a key component of the LCRM methodology. The oCM 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.

The ground model used in the oCM is also used in the assessment of geotechnical hazards which need to be overcome in the design and construction.

3.2 Ground model

The preliminary ground model presented in Section 2 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-DMRB-G CS 641 and HE-DMRB-G CD 622 Revision 1.

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

3.3.2 Plausible geotechnical hazards

Based on the expected ground conditions at the site, and the proposed design plans, plausible geotechnical hazards to be taken into account are:

- Uncontrolled Made Ground (variable strength and compressibility).
- Variable lateral and vertical changes in ground conditions.
- Adverse chemical ground conditions.
- Obstructions to excavation.
- Existing below ground structures.
- Shallow groundwater.
- Changing groundwater conditions.
- Earthworks – poor bearing capacity of new fill.
- Earthworks – unsuitability of site won material to be reused as fill.
- Solution features in soluble carbonate rock.

3.3.3 *Potential development elements affected*

Development elements potentially affected by geotechnical hazards are:

- Buildings – foundations and floor slabs.
- Pavements for roads and hardstanding
- Services.
- Retaining walls.
- Landscaped areas / gardens.
- Construction staff, vehicles and plant.
- Concrete below ground.

Health and safety risks to site contractors and maintenance workers will need to be considered separately during design and construction.

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 pollution linkages, based on the source-pathway-receptor (SPR) approach.

A viable pollution linkage requires all the components of an S-P-R linkage 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 elevated concentrations of metals, metalloids, asbestos fibres, Asbestos Containing Materials, Polyaromatic hydrocarbons (PAH) and petroleum hydrocarbons (S1).
- Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former airfield buildings (S2).
- Hydrocarbons from fuels, lubricants, and solvents including historical site uses and leakage from the former fuel underground storage tanks (USTs), the pipework connections between tanks and pumps, and general spillage, together with uncontrolled disposal and spillage of waste (S3).
- PAHs, in bituminous or coal tar bound pavements in the former taxi-ways. (S4).
- Perflurooctane sulfonic acid/Perfluorooctanoic acid (PFOS/PFOA) from use of fire retardants for example (S5).
- PCBs and oils from electricity sub-stations (S6).

- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground (S7).
- Hydrocarbon vapours from potential VOC and petroleum hydrocarbon spillages/leaks (S8).

3.4.2.2 Potential off-site sources of contamination

- Migration of hydrocarbon fuels, lubricants, and solvents from off-site fuel storage Historical Tanks and connection pipes including leakage and general spillage, together with uncontrolled disposal and spillage (S9).

3.4.3 Potential receptors

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

- People (site end users, neighbours) (R1).
- Development end use (buildings, utilities and landscaping) (R2).
- Groundwater: Secondary A aquifer status of the Cornbrash Formation (R3).
- Surface water: site drainage (R4).
- Plants / vegetation (R5).

3.4.4 Potential pathways

The following potential pathways have been identified.

- Ingestion, skin contact, inhalation of dust and outdoor air by people (P1).
- Methane ingress via permeable soils and rock and/or construction gaps (P2).
- Volatile organic compounds (VOC) and petroleum hydrocarbon vapour ingress via permeable soils and rock and/or construction gaps (P3).
- Root uptake by plants (P4).
- Migration of contaminant via leachate migration through the unsaturated zone in the Cornbrash Formation (P5).
- Migration of contaminants from the groundwater within the overlying strata to the groundwater within the Cornbrash Formation aquifer (P6).
- Abstraction and consumption by people (or other utilisation) of groundwater (P7).
- Surface water, via drainage discharge (P8).
- Surface water via base flow from groundwater (P9).

Health and safety risks to site development contractors and maintenance workers will need to be considered separately.

The above sources, pathways and receptors which have been considered as part of the Preliminary Risk Assessment in accordance with LCRM (2019), are those considered to be plausible in the context of this site and could pose unacceptable risks. These have been carried forward for assessment in the investigation as presented in Section 5. An assessment of the Source – Pathway – Receptor linkages undertaken following the assessment (Section 7) is presented in Appendix K(Table K.1).

4. GROUND INVESTIGATIONS

4.1 Investigation rationale

The ground investigation rationale was based on the findings of the preliminary geotechnical and geoenvironmental risk assessments and is summarised in Table 4-1.

Table 4-1: Investigation rationale

Location	Purpose
Bicester Heritage Hotel Site	
TP101-112	To assess shallow ground conditions generally across the site. To allow collection of samples for geotechnical characterisation and contamination testing.
TP103,106 and 110	Soil infiltration rate testing to determine the likelihood of soakaway drainage being appropriate for the site.
TP113-117	To assess shallow ground conditions. To allow collection of samples for contamination testing. To investigate for the presence of a fuel tank associated with the former fuel line inspection chambers in the west of the site.
RO101-103	To assess deeper ground conditions and to allow SPTs to be undertaken. Installation of gas and groundwater monitoring and sampling wells.

4.2 Constraints

The constraints on investigations during the period of works included:

- Low speed testing of electric cars - no investigation works were undertaken within 50 metres of the circuit whilst the test track was in use.
- High speed driver training - no investigation works took place for the duration of this event as Hydrock considered the site to be an unsafe working environment whilst the track was in use.

4.3 Site works

The fieldworks took place between 14th and 18th February 2022 and are summarised in Table 4-2.

The ground investigation locations were surveyed in using a topographic survey quality GPS and are shown on the Exploratory Hole Location Plan (Hydrock Drawing 22457-HYD-XX-DR-GE-1001) in Appendix A.

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

The weather conditions during the Hydrock fieldwork were stormy with intermittent heavy rain.

Table 4-2: Summary of site works

Activity	Method	No.	Depth Maximum / Range (m bgl)	In situ tests	Notes (e.g. installations)
Drilling, Pitting					
Boreholes	Rotary cored	3	3.00	SPT	63mm HDPE wells with gas taps in 3 holes
Trial pits	Machine (JCB 3X)	17	0.35 – 2.00	-	-

Activity	Method	No.	Depth Maximum / Range (m bgl)	In situ tests	Notes (e.g. installations)
In situ testing					
Infiltration	BRE 365	3	1.30 – 1.80	Soakaway testing	In TPs 103,106 and 110.

Wells for monitoring groundwater levels and ground gas concentrations, and to facilitate the sampling of groundwater, were installed in all of the rotary boreholes. A summary of the monitoring well installations is presented in Table 4-3.

Table 4-3: 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
RO101	83.02	50	1.00 to 3.00	82.02 to 80.02	Cornbrash Formation
RO102	82.18	50	1.00 to 3.00	81.18 to 79.18	Cornbrash Formation
RO103	81.97	50	1.00 to 3.00	80.97 to 78.97	Cornbrash Formation

4.4 Geo-environmental testing

4.4.1 Sampling strategy and protocols

Exploratory hole positions were determined by reference to the site conditions and uncertainties identified in the Initial Conceptual Model.

The immediate area around the former fuel tank and fuel line inspection chambers (see Table 4-1) were targeted for specific investigation, but a reasonably even spacing was used for the remainder of the site.

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.

4.4.2 Geo-environmental monitoring

The gas monitoring borehole installations have been monitored on all the scheduled six occasions. The results are presented in Appendix G.

4.4.3 Geo-environmental laboratory analyses

The chemical test certificates for testing undertaken by Hydrock are provided in Appendix H. Wherever possible, UKAS and MCERTS accredited procedures have been used.

The chemical test certificates for testing undertaken as part of historical investigations are provided in the relevant reports in Appendix D.

The geo-environmental analyses undertaken on soils are summarised in Table 4-4.

Table 4-4: Geo-environmental analyses of soils

Determinand Suite	Made Ground	Cornbrash Formation
Hydrock Data		
Hydrock minimum suite of determinands for solids*	12	1
Speciated aliphatic and aromatic banding Total petroleum hydrocarbons by HS-GC/MS and GC/FID (Hydrock Tier 2 TPH Suite)	12	1
Volatile organic compounds (VOC target list) by HS-GC/MS	3	1
Semi-volatile organic compounds (SVOC target list) by GC-MS	3	1
WAC Hazardous Suite	2	0

The soils chemical test data are interpreted and assessed in Sections 7.3 and 7.4.

The geo-environmental analyses undertaken on waters, leachates or other liquids for testing undertaken by Hydrock are summarised in Table 4.5.

Table 4.5: Geo-environmental analyses of waters

Determinand Suite	Ground-water
Hydrock minimum suite of determinands for waters	3
Speciated aliphatic and aromatic banding Total petroleum hydrocarbons by HS-GC/MS and GC/FID (Hydrock Tier 2 TPH Suite)	3
Benzene, toluene, ethylbenzene and xylene (BTEX) by HS-GC/MS	3
Volatile organic compounds (VOC target list plus TIC) by HS-GC/MS	3
Semi-volatile organic compounds (SVOC target list)by GC-MS	3
MTBE (Methyl Tertiary Butyl Ether) by HS-GC/MS	3
Polychlorinated biphenyls (PCB ICES 7)	3
PFAS/PFOS	3

The groundwater chemical test data are interpreted and assessed in Section 7.5.

4.5 Geotechnical testing

4.5.1 Geotechnical laboratory testing

The geotechnical tests undertaken by Hydrock are summarised in Table 4-6 and the test certificates are provided in Appendix F. 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 D

Table 4-6: Summary of sample numbers for geotechnical tests

Test	Made Ground	Cornbrash Formation
Natural moisture content	4	14
Atterberg limits	3	1

Test	Made Ground	Cornbrash Formation
Sulfate and aggressive chemical environment classification for buried concrete classification (full BRE SD1 suite)	2	7
Point Load Strength	0	6

The geotechnical test data are summarised in Section 0 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 are used from this point forward.

The general sequence of ground materials encountered was Topsoil / Made Ground, over Cornbrash Formation.

Details of the Hydrock ground investigation works are provided in the exploratory hole logs in Appendix E, data are provided in Appendix D , a summary of the ground model is presented in Table 5-1 and the individual strata are described in the sections below. Relevant cross-sections are presented in Appendix A.

Table 5-1: Strata encountered

Stratum	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m) (range)	Thickness (m) (average)
Topsoil	0.00	0.15-0.20	0.15-0.20	0.16
Made Ground	0.00-0.15	0.15->0.90	0.15->0.90	0.52
Cornbrash Formation	0.15-0.70	>0.35->3.00	>0.01->2.70	Not proven

5.1.2 Surface covering

The following surface cover was identified during the field reconnaissance and the fieldworks:

- Vegetation (grass), covering approximately 90% of the site.
- Asphalt was encountered in the south-west of the site (in TP117) to depths of between 0.00m and 0.05m, with an average thickness of 0.05m. The asphalt was in fairly worn condition with some surface scars.
- Concrete was encountered in the south-west of the site (in TP106, TP110 and TP117) to depths of between 0.05m and 0.20m, with a thickness of 150mm. The concrete contained metal reinforcing bar and appeared to be in generally undamaged condition.

5.1.3 Made Ground

Below the surface covering, Made Ground was recorded at most exploratory hole locations. Made Ground, recorded across the site to depths of between 0.15m and >0.90m, with an average thickness of 0.50m. It comprises a mixture of one of the following descriptions either brown and orangish brown slightly sandy slightly gravelly clay or clayey sandy gravel or clayey gravelly sand with gravel sized fragments of brick, asphalt and concrete.

5.1.4 Topsoil

Where the Made Ground was not encountered, in the north and south of the site, the exploratory holes encountered topsoil.

Topsoil was between 0.15m and 0.20m thick, with an average thickness of 0.17m. The topsoil comprised a mixture of brown slightly sandy slightly gravelly clay and slightly clayey sand with frequent rootlets and gravel sized fragments of flint and limestone.

For the purposes of this report, topsoil is defined as the upper layer of an in-situ soil profile, usually darker in colour and more fertile than the layer below (subsoil), which is a product of natural chemical, physical, biological and environmental processes, but does not imply compliance with BS 3882:2015. Reuse of topsoil as a growing medium at the site should be determined by the landscape architect or the landscape Contractors.

5.1.5 Cornbrash Formation

Cornbrash Formation was encountered underlying the Topsoil and Made Ground across the whole site and was proven to thicknesses of between >0.01 and >2.70m, but the total thickness was not proven. The stratum was weathered to differing degrees, but generally comprised a mixture of yellowish-brown sandy gravel with gravel and cobble sized fragments of highly weathered limestone and grey shelly limestone in the less weathered zones. Three weathering grades of the Cornbrash Formation were identified across the site during investigations, generally interbedded with each other.

Residual soil – Weathering Grade VI

Cornbrash Formation (Weathering; Residual soil Grade VI) was encountered underlying the Topsoil, Made Ground, and within the less weathered materials across the whole site. The thickness of the layers were variable, between >0.01m and >2.80m. It generally comprised a mixture of yellowish-brown sandy gravel and cobble sized fragments of limestone, with yellowish brown gravelly sand and pockets of brown sandy gravelly clay.

Completely weathered - Grade V

Cornbrash Formation (Weathering; Completely weathered Grade V) was encountered underlying the Made Ground and Residual soil in every exploratory hole across the whole site to between >0.20m and >1.80m thick, with an unproven average thickness. It generally comprised strong jointed and non-intact thinly bedded grey shelly limestone.

Slightly weathered - Grade II

Cornbrash Formation (Weathering; Slightly weathered Grade II) was encountered underlying the Residual soil Completely weathered material across the whole site and is between >0.05m and >0.80m thick, with an unproven average thickness. It generally comprised strong to very strong thinly bedded shelly limestone.

5.2 Obstructions

Obstructions were encountered in a number of trial pits during the investigation. These intrusive locations are summarised in Table 5-2.

Table 5-2: Obstructions encountered

Stratum	Location	Depth (m bgl)	Description
Made Ground	TP106	0.90	Possible old foundation concrete was encountered in the base of the pit.
Made Ground	TP110	0.40	Possible old foundation concrete was encountered in the base of the pit.
Made Ground	TP115	0.50 – 0.60	Electricity cable duct encountered in the northern face of the pit.
Made Ground	TP117	0.40	4-inch metal fuel pipe was encountered in the western face of the pit.

In addition, the Grade II weathered Cornbrash Formation limestones were too solid to allow excavation and both trial pits and boreholes were terminated where they were obstructed by the rock materials.

5.3 Groundwater

5.3.1 Groundwater observations and levels

Groundwater encountered during the investigation is listed in Table 5-3. 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 5-3: Groundwater occurrence

Stratum	Date	Location	Fieldwork	Comment
			Groundwater observation (m bgl)	
Cornbrash Formation	17/02/22	TP06(2)	1.80	Slow inflow from the eastern face of the pit.
	18/02/22	TP112	1.80	Slow inflow from the eastern face of the pit.

Groundwater levels recorded during post-fieldwork monitoring are summarised in Table 5-4.

Table 5-4: Groundwater level data summary

Stratum	Date range	Location	Post-fieldwork monitoring	
			Depth to groundwater (range) (m bgl)	Groundwater elevation (range) (m OD)
Cornbrash Formation	17/03/22 – 11/05/22	RO101	1.72 – 2.41	81.30 – 80.61
		RO102	1.35 – 2.48	80.83 – 79.70
		RO103	1.44 – 2.44	80.53 – 79.53

5.3.2 Infiltration tests

The results of the infiltration testing undertaken are summarised in Table 5-5. The results sheets are presented in Appendix E.

Testing was carried out in general accordance with BRE Digest 365 (BRE DG365) (2016), with three fillings of water for each test.

Table 5-5: Infiltration test results

Stratum	Location	Depth to base of pit (m bgl)	Infiltration rate (m/s)			
			Run 1	Run 2	Run 3	Range
Cornbrash Formation	TP103	1.80	1.18×10^{-4}	1.70×10^{-4}	1.63×10^{-4}	$1.18 \times 10^{-4} – 1.70 \times 10^{-4}$
	TP106 (2)	1.80	4.93×10^{-5}	4.05×10^{-5}	3.19×10^{-5}	$3.19 \times 10^{-5} – 4.93 \times 10^{-5}$
	TP110 (2)	1.80	2.02×10^{-4}	1.69×10^{-4}	6.99×10^{-5}	$1.69 \times 10^{-4} – 6.99 \times 10^{-5}$

5.3.3 Groundwater summary

No groundwater was encountered or monitored in the Topsoil or Made Ground.

In general, shallow groundwater was encountered in the Cornbrash Formation and the monitoring indicates there is shallow groundwater body within the Cornbrash Formation. During investigations groundwater flowed into excavations at a slow rate from an easterly direction. However, the general groundwater hydraulic gradient is likely to flow along localised drainage systems or topographically downslope towards Langford Brook located approximately 1.20km south-east of the site.

Within the Cornbrash Formation, recorded infiltration rates were between 1.18×10^{-4} and 6.99×10^{-5} m/s.

5.4 Ground gases (carbon dioxide and methane)

Records from the gas monitoring boreholes are presented in Appendix G and the results of the standard range of gases monitored are summarised in Table 5-6.

Six monitoring visits have been undertaken and the monitoring programme is complete.

Table 5-6: Range of ground gas data

Stratum	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Steady flow rate (l/hr)
Cornbrash Formation	0.1	1.1 – 2.0	16 – 20	0.0 – 0.20

In addition to the above standard gases monitored, readings were taken for other gases including carbon monoxide (CO) and di-hydrogen sulfide (H_2S). These results are summarised below.

In the first two monitoring visits (21/03/22 and 28/03/22) CO levels in RO102 were high (>500ppm and 143ppm), while levels in RO101 and RO103 were between 2 and 14ppm. In subsequent readings, between 11/04/22 and 11/05/22, CO values in all three installations were between 0 and 8ppm.

For H_2S, in the first visit RO102 recorded 16ppm. Thereafter, readings were between 0 and 1ppm.

The conclusions from the gas monitoring results are discussed in Section 7.6.

5.5 Geotechnical data

5.5.1 Introduction

Laboratory test results are contained in Appendix F with *in situ* test results shown on the relevant exploratory hole log or datasheet in Appendix E. The following sections summarise the main findings and provide interpretation where appropriate.

5.5.2 Plasticity

The volume change potentials 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 5-7.

Table 5-7: 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	1	24	24	24	16	16	16	Medium	Medium*
Cornbrash Formation (Weathering; Residual soil Grade VI)	2	27	28	27.5	16	18	17	High	Medium*

*Modified plasticity results presented in Table 5-7 indicate a low volume change potential for both strata however, due to the limited quantity of data Hydrock considers the volume change potential to be medium.

5.5.3 Soil strength – residual soil (weathering Grade VI)

Table 5-8 summarises information pertaining to the equivalent shear strength of the residual soils in the weathered Cornbrash.

The results are summarised for uncorrected Standard Penetration Tests (SPT).

A plot of SPT N60 values against depth is presented in Appendix F.

Table 5-8: Soil strength results and derived values

Stratum	No. of tests	SPT (N-value) (range)	Method
Cornbrash Formation (Weathering; Residual soil Grade VI)	3	>50	SPT – rotary boreholes.

5.5.4 CBR

Based on the classification tests undertaken it is recommended that for preliminary pavement design purposes an estimated CBR value of 2.5% for the Made Ground is used. Where the weathered Cornbrash Formation material forms the subformation, a CBR value of 5% can be used, however these should be checked by undertaking in situ CBR tests at the construction stage.

5.5.5 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 5-9. The assessment summary sheets are presented in Appendix F.

Table 5-9: Aggressive chemical environment concrete classification

Stratum	No. tests	DS	ACEC
Made Ground	2	DS-1	AC-1
Cornbrash Formation (Weathering; Residual soil Grade VI)	4	DS-1	AC-1
Cornbrash Formation (Weathering; Completely weathered Grade V)	2	DS-1	AC-1
Cornbrash Formation (Weathering; Slightly weathered Grade II)	1	DS-1	AC-1

5.5.6 *Intact material strength – rock*

Table 5-10 summarises information pertaining to the strength of the intact rock material for the limestone in the Weathering Grade V and II Cornbrash Formation, as determined by correlation from Point Load Testing to infer unconfined compressive strength (UCS). Rock strength terms follow the method of BS 5930:2015+A1:2020.

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 F. Note also that rock mass properties, rather than intact rock material properties, may be more suitable for design purposes.

Table 5-10: Intact rock strength results and derived values

Stratum	No. of tests	Point load index (Range)		UCS (MPa) (range)	Strength description	Method
		Is	$Is_{(50)}$			
Cornbrash Formation (Weathering; Completely weathered Grade V)	1	2.9	3.4	75	Strong	Axial point load
Cornbrash Formation (Weathering; Completely weathered Grade V)	1	2.4	3.0	66	Strong	Diametrical point load
Cornbrash Formation (Weathering; Slightly weathered Grade II)	5	1.4 – 3.6	1.7 – 4.7	37 – 103	Medium strong to very strong	Axial point load
Cornbrash Formation (Weathering; Slightly weathered Grade II)	5	0.5 – 4.3	0.7 – 5.3	15 – 116	Moderately weak to very strong	Diametrical point load

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 Anthony Stiff Associates drawing ASA-548-SK-808 in Appendix D. This comprises a four-storey hotel with associated parking, access roads and infrastructure, together with three earth mounds up to 1.5m high around the car park area.

At the time of writing, no structural details such as loadings have been provided, therefore the following comments are of a general nature and should be readdressed when more information becomes available.

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 J (Table J.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 considers 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.

6.3 Groundwork

6.3.1 Site preparation

The redevelopment may involve demolition of existing structures found within the site boundary. This should be undertaken to an appropriate specification, ensuring any asset materials generated are geotechnically suitable for use where this is required.

Buried obstructions were encountered during this investigation associated with foundations of old buildings, potential underground tanks and services and there is a possibility of further such obstructions being encountered.

Excavation into the Weathering Grade II and V limestone of the Cornbrash Formation is also likely to encounter obstructions.

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

6.3.2 Groundworks

Following breaking out of hardstanding and obstructions, excavation of shallow soils should be generally be feasible using conventional plant and equipment. However, excavation through any buried construction/intact rock quality strata is likely to require heavy-duty excavation plant and the use of specialist breaking equipment.

Trial pit faces were noted to remain generally vertical without collapse however, minor overbreak in the Cornbrash Formation was frequent. Trial pits reached a maximum depth of 2.00m bgl as the Grade II weathered Cornbrash Formation limestones were too solid to allow excavation. The faces of shallow, near vertically sided excavations put down at the site are likely to remain stable for short periods of time. However, it should be noted that in TP111 the sides of the excavation collapsed below 0.30m bgl in Cornbrash Formation (Completely Weathered, Weathering Grade V)

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 must be provided where entry by personnel is required.

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 and infiltration testing, the rate of water ingress to the excavations up to 2.00m bgl is likely to generally be moderate, as the ability to excavate below 2.00m depth will be limited. However, where shallow groundwater is encountered in the permeable strata of the Cornbrash Formation, sump pumping may not be suitable, and additional precautions may be required such as well-pointing. The use of trench sheeting below the base of excavations is likely to be problematic as it will be difficult to penetrate the Cornbrash strata.

Although no contaminated groundwater has been encountered in this investigation, there is still the potential that contaminated groundwater could be encountered, especially in the vicinity of former fuel tanks and pipe connections, which may not have been included in the site records. A controlled waters risk assessment in relation to contaminated groundwater is included Section 7 of this report.

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. Discharge consents may also be required, particularly if contaminated water is present. This will be assessed in the controlled waters risk assessment included in Section 7.

6.3.3 Earthworks/reuse of site-won materials

It is understood that only limited cut to fill earthworks will be required, therefore no earthworks testing has been carried out. Review of geotechnical data (see Section 0 and Appendix F) coupled with Hydrock's experience, indicates that:

- following processing to remove oversize and deleterious material the Made Ground should be suitable for reuse as general fill or landscape fill, subject to appropriate testing and completion of a Materials Management Plan if required;

- the Topsoil will not be suitable for reuse as engineered fill due to high organic matter content but may be used as Landscape Fill (subject to the Materials Management Plan) in parts of the site not sensitive to settlements;
- the Cornbrash Formation is likely to be Class 1 (Granular)/Class 2 (Cohesive) and may be suitable as landscape fill or general fill. However, the less weathered materials and where grain sizes >20mm are present, these will need to be crushed or screened.

If significant engineered earthworks are proposed, additional earthworks testing and Specification will be required as a supplementary stage of works.

6.4 Mineworkings

No evidence of mineworkings or mine entries is recorded within the site area. In addition, no evidence of mineworkings was detected during site investigations.

However, it should be noted that unrecorded mineworkings may be present beneath the site given the underlying geology and historical limestone quarries recorded in the surrounding area around the site. Should evidence of mineworkings be discovered during the groundworks, works are to cease immediately and Hydrock is to be contacted.

6.5 Foundation recommendations

The following foundation recommendations are presented to aid development proposals only and separate geotechnical design will be required if they are assessed as Geotechnical Category 2.

To date, no foundation loadings are available, and data regarding the serviceability limit state i.e. total and differential settlement tolerances) for the structure have not been provided. The following recommendations are of a general nature and should be reviewed at the design stage.

6.5.1 Foundation Types

The Made Ground 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 and should be fully penetrated by all new foundations or excavated, screened, processed and re-engineered to create the development platform.

On the basis of the ground conditions indicated from the current investigation, it is considered that shallow spread foundations for the proposed development are likely to be suitable, in the form of pad foundations for structural columns or strip foundations for load-bearing walls.

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.

6.5.2 Spread foundations

Pad foundations should be founded at least 300mm into the competent materials of the Cornbrash Formation.

For preliminary design, a permissible net bearing pressure of 200kPa for the Cornbrash Formation is recommended for pad foundations of up to 2.0m by 2.0m, or strip foundations up to 1.0m wide.

In order to take account of the presence of medium volume change potential clay soils in the residual soil stratum, the minimum founding depth for pad foundations should be below the base of the Made Ground and 0.90m below final ground level, whichever is deeper. 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. Deepening of foundations in accordance with BRE 240 and BRE 298 will be required where pad foundations are within the zone of influence of existing, removed or proposed trees and proposed shrub planting. NHBC Standards (Chapter 4.2) should also be taken into account. 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.

Where foundations are on limestones of the Weathering Grade II or better, or where the thickness of residual soil under the foundation is limited, it is likely that a higher permissible bearing pressure will be possible, particularly if foundations are deepened down to competent rock strata. In general, where the limestone was weathered to residual soil Grade VI, its thickness was limited and the risk of significant settlement is limited. However, it is not possible to predict the precise ground conditions at any position due to the variability of the depths and extent of the different weathering zones. Therefore, for preliminary purposes, a conservative permissible bearing pressure of 200kPa is recommended at this stage to take into account the possible settlement of uncemented weathered zones.

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 a suitable stratum of competent limestone.

Foundation excavations should be protected from rain and freezing conditions and inflow of surface water. The Cornbrash Limestone should be assumed to be frost susceptible, and should therefore be well protected from exposure to 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. Should sump pumping be unsuitable, additional precautions may be required such as well-pointing. Groundwater may be locally contaminated due to leakage from fuel pipes, tanks etc., although none has been detected from the current works. Water removed from excavations should be passed through a settlement and filtration process prior to discharge to sewer or surface water drainage.

The Made Ground and Cornbrash Formation (Weathering; Residual Soil Grade VI) contains clay, which can swell and soften in contact with water. Therefore, foundation excavations should be kept free from water and foundation concrete should be poured as soon as practicable after excavation.

If the recommended permissible net bearing pressure for spread foundations is considered insufficient for the proposed development, a more detailed design including settlement analysis for spread foundations utilising the anticipated structural loadings is required.

In the event that the column loadings are too high to allow traditional shallow spread foundations and a sufficient bearing pressure cannot be determined, consideration could be given to enlarging and/or deepening the foundations into more competent rock, and reducing the applied foundation pressure.

It is unlikely that piles will offer a suitable solution due to the difficulty of constructing piles through the strong and very strong bans of limestone in the Cornbrash Formation to achieve a depth which is suitable for vertical and lateral support. Therefore, no further consideration of piles is given in this report. However, should further consideration be required, Hydrock should be consulted.

6.6 Ground floor slabs

Subject to geotechnical design and on the basis that excavation and replacement of unsuitable shallow soils such as Topsoil, Made Ground and loose Residual Soil Grade Vi weathered Cornbrash Formation, will be undertaken, and subject to all structural fill being placed and compacted in accordance with an appropriate specification, then ground bearing floor slabs may be adopted.

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 should be inspected and checked by a competent person to ensure the ground conditions at time of construction are consistent with 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 DMRB IAN 73/06. It is recommended that the verification of the sub-formation and formation include, as a minimum, the measurement of modulus of sub-grade reaction (k) determined by static plate load testing.

Alternatively, a suspended floor slab system could be adopted, supported on ground beams between the foundation elements.

Ground floor slabs should be designed to incorporate any gas mitigation measures that may be required, as discussed later within this report.

6.7 Roads and pavements

Based on CBR testing carried out and plasticity index correlation in accordance with IAN 73/06 Rev 1, it is considered likely an equilibrium CBR of <2.5% should be used for the Made Ground. If this is over-excavated and replaced with suitable subgrade material placed and compacted to an appropriate specification, a CBR value of 5% should be achievable.

Proof rolling of the formation level should be carried out and any loose or soft spots should be removed and replaced with an engineered fill, in accordance with a suitable specification. The formation level should be protected during inclement weather from deterioration; all 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 by a geotechnical engineer or engineering geologist 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 DMRB IAN 73/06 Rev 1 Chapter 5. 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 they are deemed suitable for treatment with hydraulic binders, to employ modification and/or stabilisation techniques on the formation; and
- where granular soils are present, de-watering and re-engineering the formation.

6.8 Drainage

Indicative infiltration rates for the ground investigation are presented in Appendix G and are summarised in Table 5-5.

Soakaways or infiltration as part of a Sustainable Urban Drainage System (SUDS) is considered suitable for the site based on the tested infiltration rates, subject to detailed drainage design by a specialist. However, it should be borne in mind that whilst the Cornbrash Formation has a high porosity and provides a reasonable rate of infiltration, the limestone which it comprises is soluble in acidic rainwater and in order to protect against the risk of creating solution cavities with an associated risk of collapse, which could result in subsidence, it is recommended that soakaways are kept at least 5m away from any building foundation, in the proposed development, or other buildings. They should also be kept away from other structures sensitive to settlement such as gravity drainage runs.

6.9 Buried concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005) and the information presented in Section 5.5.5 (Table 5-9) the following recommendations are provided for the design of buried concrete in relation to aggressive ground conditions:

- The Made Ground can be classified as Design Sulfate Class DS-1 and ACEC Class AC-1.
- The Cornbrash Formation can be classified as Design Sulfate Class DS-1 and ACEC Class AC-1.

This equates to a Design Chemical Class[1] of:

- DC-1 for the shallow soils (Made Ground);
- DC-1 for the deeper soils (Cornbrash Formation); and

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

[1] 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 preliminary ground model developed from the desk study and field reconnaissance survey (Section 2) has been updated using the findings of the ground investigation and is presented in Section 5. This ground model is the basis for the geo-environmental assessment presented in this section.

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 2.15), have been updated or confirmed as follows.

7.1.2.1 Sources

No potential sources have been removed from, or added to, the exposure model. However, there is a risk that further unrecorded features such as buried fuel tanks, connection pipelines, services, and other buried structures and services could be encountered during the construction works.

7.1.2.2 Receptors

No potential 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

Generic risk assessments have been undertaken in accordance with the principles of LCRM (Environment Agency, 2019) using the Conceptual Model (CM) that has been updated following the ground investigation.

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'). Where screening values are exceeded, the result has been evaluated in association with other pertinent information to determine whether the exceedance is unacceptable in the site-specific circumstances. Further explanation is presented in Appendix L.

The data sets used in the assessment comprise the analytical results obtained by Hydrock as listed in Section 4.

7.3 Human health risk assessment

This is a Tier 2 assessment using soil screening values applicable to the commercial CLEA land use scenario.

The soil screening values used are generic assessment criteria (GAC). It should be noted that Category 4 Screening Levels (C4SL) for lead have been used as there is no recognised GAC for lead and the use of the term 'GAC' in this report includes the C4SL for lead.

Statistical testing is used where data sets are suitable. The critical issue is sample numbers. For data sets with low sample numbers and / or where sampling is targeted at specific areas, individual sample test results are compared directly with the screening values. Larger and non-targeted data sets are subject to statistical testing.

The phrase 'further assessment required' is used to denote soil concentrations that are equal to, or 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'.

The results of the assessment are presented in Appendix H.

7.3.1 Averaging areas

The 'averaging areas' used in this report are based on the conceptual model and the proposed development, and are summarised as:

- the immediate area around the former fuel tank and fuel line inspection chambers; and
- the wider site.

The 'averaging areas' data are separated into;

- Topsoil;
- Made Ground; and
- Cornbrash Formation.

7.3.2 Risk assessment

7.3.2.1 Chemicals of potential concern

Based on individual test results, no chemicals of potential concern were reported in excess of the GAC and/or above the laboratory limit of detection and therefore, do not require further assessment.

7.3.2.2 Asbestos

No visual evidence of Asbestos Containing Materials (ACM) was encountered during investigation works and the laboratory test data indicates no detected asbestos in the samples screened and tested.

Whilst Hydrock consider it plausible for asbestos to be present in any of the Made Ground soils, overall, the risk associated with the potential presence of asbestos is considered to be low.

7.4 Plant life risk assessment

7.4.1 Risk assessment

Priority phytotoxic chemical concentrations have been screened against published values to determine the likely risk to plant growth and the findings presented in Appendix H.

Within the soils, concentrations of COPC were below the GAC. 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. The vegetation on site did not show any signs of physical distress, Hydrock does not consider there to be an unacceptable risk to existing or proposed vegetation from contamination and no additional consideration is required with regard to risks to plant life.

7.5 Pollution of controlled waters risk assessment

7.5.1 Risk estimation

The risks to groundwater and surface water from contaminants on site have been assessed in accordance with the Environment Agency (2006) Remedial Targets Methodology (RTM).

Site contaminant loadings are compared with relevant screening values (Water Quality Targets), which are linked to the Conceptual Model.

Acceptable WQT are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)).

As related specifically to this site, the data are compared with criteria selected in accordance with the methodology presented in Appendix L. This methodology involves selecting which of several alternative risk scenarios apply in this case. The assessment is presented in Table 7.1 below, with the justification for the scenarios selected explained in the following text:

- The Cornbrash Formation underlying the site is classified as a Secondary A aquifer. The closest groundwater abstraction is location approximately 350m north of the site. The site is not located above a groundwater Source Protection Zone (SPZ) or within the 500m buffer zone of an SPZ.
- The closest surface water feature is Langford Brook located approximately 1.2km east of the site. Groundwater from the site will likely migrate downgradient via baseflow in an easterly direction towards Langford brook.

Table 7.1: Summary of water quality risk assessment protocol

Hydrock scenario	Water body receptors	Secondary receptors	Example contaminant linkages	RTM level and data used	Water quality targets
D	Groundwater. Surface water.	Human health (abstraction). Aquatic ecosystem.	Contaminants from site leach or seep into a groundwater body that feeds inland surface water by base flow. The surface water may be used for human consumption and is an aquatic ecosystem.	RTM Level 2 – Groundwater. Direct comparison of surface water samples	DWS EQS (inland)
Notes: Some EQS are water hardness dependent. This is measured either in the receiving surface water or in groundwater (if it is part of the pathway), or is estimated from national maps. Inland waters EQS applicable to freshwater, 'other' waters EQS applicable to coastal or transitional waters. This table and the results of the assessment are considered as a first screening for potential risks of pollution of Controlled Waters. More specific requirements may be stipulated by the relevant Agency.					

The results of the screening assessment are presented in Appendix H and are summarised in Table 7.2.

There are no WQT for petroleum hydrocarbon fractions in water. However, because of the sensitivity of the water environment to petroleum hydrocarbons, an initial screening exercise is also included in Table 7.2 irrespective of the assessment scenario(s) stated in Table 7.1.

In some instances, the reporting limit (or detection limit) quoted by the laboratory may be greater than the WQT that it is being assessed against. As the current exercise is an initial screening assessment, further assessment of these elements has not been undertaken.

Table 7.2: Chemicals of potential concern for which further assessment is required (controlled waters)

Chemical of potential concern	Water quality target (WQT) (µg/l)	Basis for water quality target	No. samples	No. samples above LoD	Min. (µg/l)	Max. (µg/l)	No. samples exceeding WQT and above LoD
Groundwater Data							
Copper	1	EQS bio †	3	3	1.4	1.5	3
Nickel	4	EQS bio †	3	2	4.2	4.3	2
Note: the maximum recorded value is compared with the water quality target. † The EQS for these substances represents a bioavailable concentration, which will be a proportion of the actual dissolved concentrations in water. No site-specific bioavailablity testing was able to be undertaken at the site and therefore the EQS bioavailable represents a conservative screening approach.							

7.5.2 Risk evaluation

The EQS for copper (maximum value of 1.50 µg/l when compared to the EQS 1.00 µg/l in three boreholes) and, nickel (maximum value of 4.30 µg/l when compared to the EQS 4.00 µg/l in two boreholes) are exceeded.

Whilst there are exceedances of the water quality targets, these exceedances are considered not to represent a significant risk of pollution of Controlled Waters from an on-site source as there is no evidence of artificial accumulations of these substances on the site.

Furthermore, the inland waters EQSs for copper and nickel are based on the bioavailable fraction and because bioavailability has not been calculated for these metals the assessment is conservative as it assumes 100% bioavailability.

It would be technically challenging and probably disproportionately costly to remove these natural contaminants from the water or to prevent further infiltration.

Hydrock believes that the risks to Controlled Waters do not need further consideration.

7.6 Ground gases risk assessment

7.6.1 Data

Based on the desk study evidence, the risk of ground gas generation at the site detailed in the preliminary conceptual site model (PCSM) is low. There are no potentially significant sources of ground gas generation within the site or in its vicinity.

In addition, the ground investigation did not reveal any significant foreseeable sources of ground gas, confirming the PCSM.

The six monitoring rounds confirmed generally low levels of methane and carbon dioxide gas and close to normal levels of oxygen, hence confirming the low risk to the development from these routinely considered types of ground gas.

However, the gas monitoring results for carbon monoxide (CO) and to a lesser extent, hydrogen sulfide (H_2S) are anomalous and are discussed further as follows.

Carbon monoxide is a colourless, odourless, tasteless, poisonous gas produced by incomplete burning of carbon-based fuels, including gas, oil, wood and coal. However, there is no evidence for these conditions existing at the current site, and it was not predicted in the preliminary conceptual site model. The sources of the CO and H_2S detected are not known.

The monitoring instrument was in calibration so the readings cannot be discounted. The CO levels decreased significantly after three weeks after which they were all below 8 ppm.

As defined in HSE EH40/2005 Workplace exposure limits, the short-term workplace exposure limit for CO is 100pm and the long-term workplace exposure limit is 20ppm. The long-term readings are well below the long-term workplace exposure limit, however under the Control of Substances Hazardous to human Health (COSHH) regulations, it is necessary to protect against the risks from CO.

Hydrock has undertaken six readings, including during periods of falling atmospheric pressure, but none have been during periods of low atmospheric pressure. As such, the conclusions presented below may not reflect worst-case conditions.

7.6.2 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, which cites the guidelines published by CIRIA (Wilson et al 2007) (known as Situation A).

The assessment guidelines published by CIRIA are based on interpretation of the concentrations and the gas flow rates for methane and carbon dioxide, amongst other variables, and are compliant with the model procedures of LCRM. The modified Wilson and Card assessment has been used by comparing the maximum gas concentrations and gas screening values (GSV[2]) in Appendix D with the published table (CIRIA Table 8.5) and the assessment is summarised in Table 7-3. The assessment is presented in Appendix G.

Table 7-3 summarises a ternary plot assessment of the data (assessment of ground gas ratios (O_2 + N_2, CO_2 and CH_4)), undertaken in general accordance with guidance by Wilson et. Al. (2018).

Table 7-3: Ground gas risk assessment

	Min	Max	Typical [(i)]	Comment
Steady Flow Rate (l/hr)	0.1	0.2	0.2	-
Methane (%)	0.1		<1	
Carbon Dioxide (%)	1.1	1.9	<5	
Oxygen (%)	15.9	20.1	>16	-
Carbon Dioxide GSV (l/hr)	0.0040		<0.07	CS1

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

	Min	Max	Typical [i]	Comment
Methane GSV (l/hr)	0.0002		<0.07	CS1

(7) Hydrock assume that values are considered to be atypical if 95% or more of the remaining data are less than the value under consideration

For the purposes of the calculation, where the recorded gas flow rate is below the manufacturer's limit of detection for the instrument used, the detection limit has been adopted for the gas flow rate.

As indicated in Table 7-3, the computed GSV for carbon dioxide and methane indicate CS1 conditions and methane and carbon dioxide at concentrations are 'typically' below 1% and 5% respectively. As such, the site would normally be classified as Characteristic Situation 1 (Situation A), whereby mitigation measures would not be necessary.

However, as mentioned previously, the first three gas monitoring visits recorded significantly elevated carbon monoxide (143ppm – 500ppm in RO102, and 5ppm-419ppm in RO103). Hydrock has undertaken, in total, six gas and groundwater monitoring visits to assist in the assessment of the risk posed by carbon monoxide and the appropriate mitigation measures. Monitoring results from the latest three visits recorded no instances of significantly elevated carbon monoxide, with results between 0ppm and 8ppm, all being below the workplace long term exposure limit. In addition, no evidence of carbon monoxide generating sources was identified at desk study stage or during investigations.

There was also a reading for H_2S in borehole RO102 of 16ppm from the first monitoring visit. Thereafter, the subsequent H_2S readings were all 0 – 1ppm which is below the workplace long term exposure limit of 5ppm.

Hydrock considers that the risk posed by carbon monoxide to the proposed development is low, but without further more detailed assessment, it should be taken into account and it is therefore necessary to upgrade the Characteristic Situation from CS1 to CS2. Further details are provided in Section 7.10.

7.6.3 Off-site risks from carbon dioxide and methane

The National Planning Policy Framework requires that a developed site should be incapable of being determined as Contaminated Land as defined under Part 2A of the Environmental Protection Act 1990. This position includes a consideration of the potential for off-site migration of ground gases that may impact on adjacent properties.

Consequently, it may be necessary to consider the imposition of measures to protect adjacent, off-site receptors. In this case the risk from site-derived ground gas is low.

It is considered that the site is not Contaminated Land as defined above.

7.7 Construction materials risk assessment

7.7.1 Potable water supply pipes

A formal water pipe investigation and risk assessment for supply pipes for potable water 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, to give an indication of the possible restrictions to the use of plastic pipes for water supply to the site (see the reference in Appendix L for further information).

The site falls within the definition of Brownfield Land. However, the investigation has not detected organic contamination in exceedance of the threshold values and Hydrock considers standard pipework

may be suitable for potable water supply pipes at the site. However, confirmation should be sought from the water supply company.

7.7.2 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 BTEX are below 100mg/kg and the concentrations of petroleum hydrocarbons (TPH) are below 200 mg/kg, PVC-U, PP or PE pipework is considered suitable.

The implications for buried concrete in aggressive ground conditions are discussed in Section 6.9.

7.8 Contamination risks to ground workers

7.8.1 Introduction

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

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. 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.

7.8.2 Metals, metalloids, PAH and petroleum hydrocarbons

Laboratory testing indicates no elevated concentrations of metals, metalloids and PAH in soil or groundwater samples, when compared to the GAC/DWS/EQS.

7.8.3 Ground Gas

Recorded concentrations of carbon dioxide (an asphyxiant) in the soil do not exceed HSE Workplace Exposure Limits for personnel in the working environment of 1.5% for short term (15 minutes) exposure and / or 0.5% for long term exposure. However, 8 out of the 10 soil concentrations of oxygen recorded 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. All necessary health and safety precautions should be followed when working in trenches or confined spaces.

7.8.4 Vapours

No significant odours were recorded during investigations and laboratory testing of soils detected no VOC or SVOC concentrations were in exceedance of the GAC.

There is a risk of volatilisation from the soils and groundwater, especially in confined spaces and risk assessments and method statements should be in place if vapours and odours are identified during excavation. Additional guidance can be found in EH40/2005 Workplace Exposure Limits (HSE 2011).

7.8.5 Asbestos

As no clearly identifiable ACM has been seen during the site walkover or during the ground investigation and no fibres have been detected in soil samples analysed by laboratory testing, CAR2012 does not apply. However, there is always the possibility of unexpected contamination and the Contractors should undertake a watching brief during the works. If any suspect material is encountered, works in that area of the site should stop, the area fenced off and Hydrock should be notified.

7.9 Findings of the generic contamination risk assessments

The potential sources, pathways and receptors identified in the desk study (Section 2)and have been investigated (Sections 4 and 5) and assessed (Sections 7.2 to 7.7). A Source-Pathway-Receptor linkage assessment has been undertaken and is presented in Appendix K (Table K.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 7.4.

Table 7.4: Residual risks following risk evaluation

Contaminant Linkage				Comments	
Pollutant Linkage	Sources	Pathways	Receptors	General	Mitigation
PL 1.	Carbon Monoxide in the soils beneath the site	Migration through soils or groundwater to indoor air.	End users of new buildings (asphyxiation).	Characteristic Situation 2.	Mitigation required by the construction of a subfloor void and installation of suitable gas resistant membrane. To be installed by trained installer. To be validated and verified.

Investigations were undertaken as close as was practicable around the perimeter of the aviation fuel line inspection chambers. These investigations concluded that a hollow structure (possibly associated with the aviation fuel line) may be present beneath the inspection chambers however, it's lateral extent would appear limited. Any unrecorded UST's and associated pipework, whilst considered unlikely based on the evidence of the ground investigation and review of historical maps, may be present and could be located during excavation works for the proposed development. Therefore, if recorded, a discovery strategy may be prudent to be in place to manage the works.

If the former taxi-ways were to be excavated as part of the proposed development, the bituminous bound material must be stockpiled separately and chemically tested before re-use/disposal. This material may contain coal tar based binding products from town gasworks sources, which may contain

high levels of PAH and other toxic compounds. Further testing should be carried out to assess whether these can be reused and for disposal purposes. It is considered unlikely however that any works will be undertaken on the former taxi-ways.

7.10 Gas mitigation protection measures

Mitigation of the risk from ground gases should be undertaken in accordance with BRE 414, CIRIA 665, BS 8485:2015 +A1:2019, CIRIA C748 and CIRIA C735. In accordance with BS 8485:2015 +A1:2019, the design of gas protection measures should be undertaken in accordance with the Characteristic Situation and the building type:

- In view of the recorded presence of carbon monoxide in the ground gas, the site is provisionally classified as Characteristic Situation 2.
- The hotel is classified as a Type C building.

As such, 2.5 points of protection as required, as illustrated in Table 7.5.

Table 7.5: Gas protection score by CS and type of building (after BS 8485:2015 +A1:2019)

Characteristic Situation	Minimum gas protection score (points)			
	High risk		Medium risk	Low risk
	Type A building	Type B building	Type C building	Type D building
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5(A)	5.5(A)	4.5	3.5
5	_	6.0	5.5	4.5
6	_	_	_	6.0

The final design of ground gas protection measures is to be specified by the designer in accordance with CIRIA 665, CIRIA C748 and BS 8485:2015 +A1:2019. The protection can be achieved by a combination of two or more of the following three types of protection measures:

- the structural barrier of the floor slab, or of the basement slab and walls if there is a basement present;
- ventilation measures; and
- gas resistant membrane.

Where design elements are required to meet certain standards to qualify for the protection points (e.g. cast *in situ* monolithic reinforced floor slab), it is up to the designer to ensure the minimum requirements of the standards are met.

Where used, gas resistant membranes should be:

- sufficiently impervious to methane, carbon dioxide and carbon monoxide;
- capable, after installation, of providing a complete barrier to the entry of the relevant gas;
- sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;

- sufficiently strong to withstand in service stresses (e.g. due to ground settlement if placed below a floor slab);
- sufficiently strong to withstand the installation process and following construction activities until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, and dropping tools); and
- chemically resistant to degradation by other contaminants that might be present.

As preliminary guidance, Hydrock would suggest the following:

Either:

- Beam and block or pre-cast concrete floor slab (0 points);
- passive sub floor ventilation e.g. void (good performance 1.5 points); and
- 2000g gas resistant membrane (2.0 points). The membrane needs to provide a hydrocarbon and VOC vapour barrier.

Or:

- Cast *in situ* ground-bearing floor slab (with only nominal mesh reinforcement) (0.5 points);
- 2000g gas resistant membrane (2.0 points). The membrane needs to provide a hydrocarbon and VOC vapour barrier.

Other variations are possible. It is up to the designer to design and specify ground gas protection measures.

Choice of the specific vapour barrier should be made by the designer in association with the membrane supplier, following additional risk assessment in accordance with CIRIA C748.

Where a gas resistant membrane is required as part of the design, all joints and penetrations should be sealed and the installation is to be verified in accordance with CIRIA C735 (Mallet et al 2014) or it will score zero points and will not be deemed to afford any protection. This verification will involve verification by the Contractor and independent verification on a selected number of plots by Hydrock or alternative qualified independent third-party.

Whilst tape can be utilised to seal the seams Hydrock would recommend the membranes are sealed using welded seams and the use of specialist seals around penetrations (top hats etc.). The installer is to present an installation methodology and a QA/QC plan for installation to Hydrock for comment, with particular attention given to sealing the membrane.

In order to achieve the points specified for ventilation, the architect is to design passive ventilation to meet at least 'good performance', as described in Annex B of BS 8485:2015 +A1:2019.

It is possible with further monitoring and assessment by a specialist in carbon monoxide in connection with gas protection measures, that the risk from CO could be discounted and the need for gas mitigation removed. However, based on the current data, the above conservative approach is recommended.

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 offsite disposal of the material as a waste and/or 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 8.3 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.

Topsoil

Topsoil is biodegradable, therefore if it is surplus to requirements and cannot be re-used in accordance with a Materials Management Plan, it cannot be classified as inert. As such, topsoil should be classified by a staged assessment and sampling process and classified as either Hazardous or Non-hazardous, depending upon the results of the assessment.

Contaminated or potentially contaminated (brownfield) sites

As the site is brownfield, contaminated or potentially contaminated waste must undergo an initial waste classification exercise using background information on the source and origin of the waste and assessment of chemical test data in accordance with Environment Agency Technical Guidance WM3.

If following the initial waste classification exercise, the soils are acceptable for disposal to a non-hazardous landfill, further qualitative Waste Acceptance Criteria (WAC) testing is not required.

However, if soils are potentially able to be disposed to an inert landfill as non-hazardous waste, or require testing to determine if they can be disposed of to a stable non-reactive hazardous or hazardous class of landfill, the next stage of assessment is to undertake qualitative WAC testing. This will determine the Basic Characterisation and the landfill category at which the soils can be accepted.

Hazardous material must be subjected to WAC testing to determine whether it requires treatment before it can be accepted at the hazardous landfill, while non-hazardous material can be tested to determine whether it may be suitable for placement in an inert landfill.

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 I and a summary of the preliminary waste classification is provided below in Section 8.2.4.

The HazWasteOnline™ has assessed that all Made Ground samples taken on site are classified as 'Non-Hazardous Waste'.

8.2.3 WAC Testing

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

8.2.4 Preliminary waste disposal options

Based on the site history, WAC 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 is likely to be classified as 'non-hazardous waste' based on the HazWasteOnline™ assessment. WAC testing in this Made Ground indicates a waste classification of 'Inert Waste Landfill'.
- Any soils containing > 0.1% asbestos or visible asbestos containing materials would be considered as Hazardous.

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[3]:
  - » 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 Materials management

8.3.1 Introduction

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

[3] ENVIRONMENT AGENCY. November 2010. Guidance on waste acceptance procedures and criteria. Waste acceptance at landfills. The Environment Agency.

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.

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.

8.3.2 Materials management scenarios

The materials management scenarios present on site are discussed below.

It should be noted that more than one scenario may apply, dependent upon where the soils are proposed for reuse.

8.3.2.1 Clean, naturally occurring materials – reused on the site of origin

Where soils are naturally occurring, uncontaminated and are reused on the site they are excavated (i.e. greenfield site with documented site history, with no Made Ground), they will fall outside the Waste Framework Directive (WFD) (i.e. they will not be a waste when reused on the site of origin).

However, there needs to be certainty of that reuse, and evidence is necessary to support this strategy, for example through information provided during the planning process. The onus is on the developer to

demonstrate that the materials are not a waste and will never become a waste. As such, a Materials Re-use Strategy is recommended to show certainty. Alternatively, if the volume of material is under 1,000 tonnes, then a U1 waste exemption may be applied for from the Environment Agency.

It may be noted that some 'clean naturally occurring materials' may still fail the 'suitable for use' test, for example, soils with a naturally high organic content may not be suitable for use because of their propensity to produce ground gases such as methane. Rules regarding other more unusual circumstances such as where natural soils contain an unacceptably high mineral content are described in the DoWCoP.

8.3.2.2 Made Ground and other contaminated soils

On sites where Made Ground or contaminated soils are present, any soils excavated will be a waste as soon as they are excavated (even if they are clean, naturally occurring materials), unless they are subject to reuse in accordance with the DoWCoP. As such, for any brownfield site or a site where Made Ground is present and soils are being moved and reused, the materials could be deemed a waste, subject to either:

- a Materials Management Plan (MMP), to prevent the material being classified as a waste following reuse; or
- an exemption (for limited volumes); or
- an environmental permit, dependant on its status.

Other commonly occurring circumstances are:

If Made Ground is being moved between sites, it must be ensured that appropriate permits are in place to ensure the soils are not classified as a waste. Made Ground cannot be moved between sites under DoWCoP alone and would require relevant permits as part of the MMP documentation for the Hub site the material is being treated at.

8.3.2.3 Made Ground and other contaminated soils

All recycled materials (6F2 etc.) must be produced under the 2013 WRAP 'Quality Protocol: Aggregates from inert waste', whether on site or off-site. If they are not, they will be deemed a waste and can only be used on site under a permit. More information can be found at https://www.gov.uk/government/publications/quality-protocol-production-of-aggregates-frm-inert-waste.

8.3.2.4 Geotechnical improvement requirements

Construction activities carried out on uncontaminated soils solely for the purpose of improving geotechnical properties e.g. lime / cement modification, are not generally regarded as waste treatment operations and do not require a permit.

However, should processing be needed (such as screening, treatment or improvement), that would constitute a waste activity and require a mobile treatment permit. This may be as simple as removing oversize material with an excavator bucket, to using a riddle bucket to remove hardcore to full mechanical screening.

9. UNCERTAINTIES AND LIMITATIONS

9.1 Site-specific comments

The constraints on investigations during the period of works included:

- Low speed testing of small-scale electric cars – no investigation works were undertaken within 50 metres of the circuit whilst the track was in use.
- High speed driver training – no investigation works took place for the duration of this event as Hydrock considered the site to be an unsafe working environment whilst the track was in use.

A number of obstructions were encountered within trial pit excavations which included:

- Trial pit TP106 was terminated at 0.90m bgl as a linear concrete feature (possible historical foundation) was encountered in the base of the pit.
- Trial pit TP110 was terminated at 0.60m bgl as a linear concrete feature (possible historical foundation) was encountered in the base of the pit.
- Trial pit TP115 was terminated at 0.60m bgl as an electricity cable duct was encountered in the northern face of the pit.
- In trial pit TP117 a 4-inch metal fuel pipe was encountered in the western face of the pit at 0.40m bgl.

9.2 General comments

Hydrock Consultants Limited (Hydrock) has prepared this report in accordance with the instructions of IKS Consulting on behalf of Bicester Motion (the Client), by e-mail dated 24th January 2022 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 February 2022. 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 reports 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. The various methodologies used are referenced in Appendix L. 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 are recommended:

- Discussion and agreement with utility providers regarding the materials suitable for water supply pipework;
- Discussions with regulatory bodies and other relevant parties regarding the conclusions of this report;
- Assessment of foundation recommendations when further details of the structural loadings and limit state criteria are available;
- Assessment of tree influence with regard to planting proposals on foundations and design of foundations as part of the geotechnical design;
- Provision of geotechnical design for the Category 2 structure (earthworks, retaining, floor slabs, foundations etc.);
- Production of a Materials Management Plan relating to reuse of soils at the site and import of soils to the site;
- A Materials Management Strategy relating to reuse of soils at the site;
- Production of a Remediation Strategy and Verification Plan (and agreement with the regulatory bodies and the warranty provider);
- remediation and mitigation works; and
- verification of the remediation and mitigation works.

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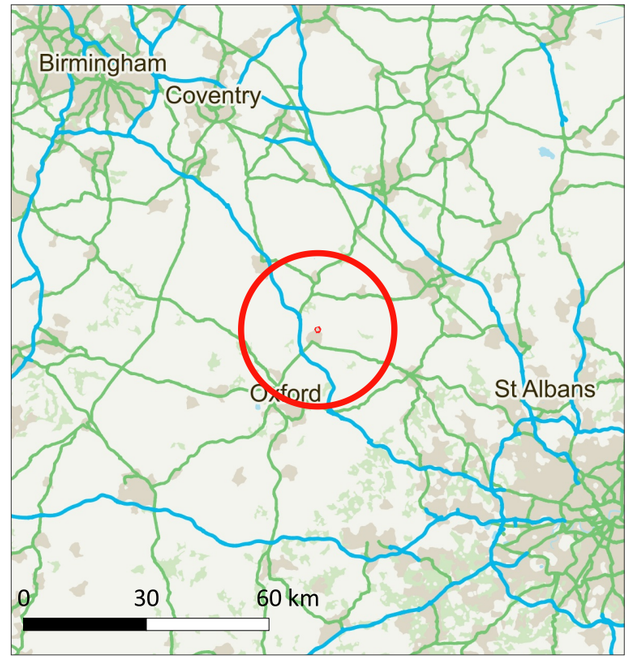
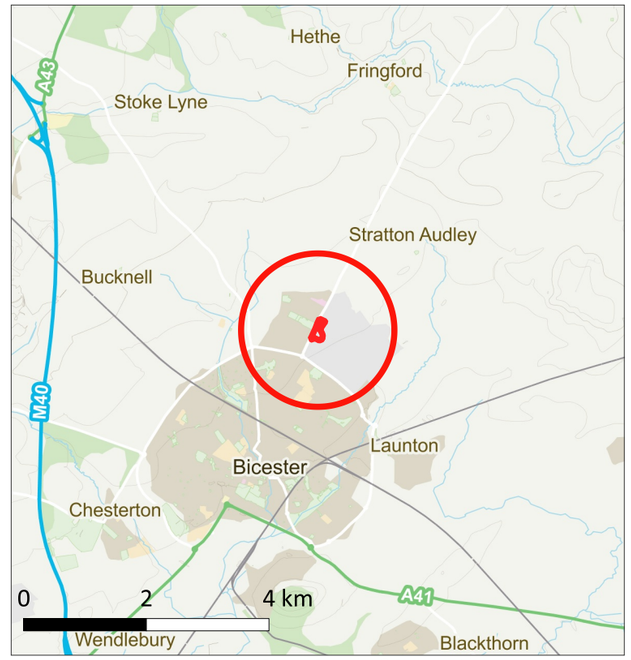
Appendix A Drawings





KEY PLAN

Site Boundary

NOTES

1. Contains OS data © Crown copyright and database right (2021)

REVISIONS

REV.	DRAWN BY INITIALS	CHECKED BY INITIALS	DATE	REVISION NOTES/COMMENTS
P01	CLD	MT	25/01/22	First issue

Hydrock

TITLE
SITE LOCATION PLAN

HYDROCK PROJECT NO.
22457

SCALE @ A3
1:10,000

CLIENT
Bicester Motion

PURPOSE OF ISSUE
SUITABLE FOR INFORMATION

STATUS
S2

PROJECT
Bicester Heritage Hotel

DRAWING NO.
22457-HYD-XX-XX-DR-GE-1000

REVISION
P01

ID	Type	X (Easting)	Y (Northing)	Proposed Depth (m)	Installation	Soakaway
TP113	TP	459184.17	224676.66	3	N	N
TP114	TP	459181.27	224682.2	3	N	N
TP101	TP	459289.44	224900.72	3		
TP102	TP	459298.2	224848.02	3		
TP103	TP	459239.19	224819.54	3		Y
TP104	TP	459262.38	224776.11	3		
TP105	TP	459225.79	224745.96	3		
TP106	TP	459282.48	224727.41	3		Y
TP107	TP	459209.03	224709.37	3		
TP108	TP	459233.78	224680.76	3		
TP109	TP	459313.15	224670.58	3		
TP110	TP	459168.83	224656.53	3		Y
TP111	TP	459212.64	224647	3		
TP112	TP	459255.42	224601.77	3		
RO101	RO	459255.68	224714.39	3	Y	
RO102	RO	459218.05	224621.48	3	Y	
RO103	RO	459295.37	224612.33	3	Y	

KEY PLAN

Site Boundary

Proposed Locations [17]

- Trial Pit [14]
- Rotary Open [3]
- Soakaway [3]
- Installation [3]

NOTES

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REVISIONS

REV.	DRAWN BY INITIALS	CHECKED BY INITIALS	DATE	REVISION NOTES/COMMENTS
P01	MT	AB	09/02/22	First issue

Hydrock

TITLE: PROPOSED GROUND INVESTIGATION PLAN

HYDROCK PROJECT NO.: 22457

SCALE @ A3: 1:2,000

CLIENT: Bicester Motion

PURPOSE OF ISSUE: SUITABLE FOR INFORMATION

STATUS: S2

PROJECT: Bicester Heritage Hotel

DRAWING NO.: 22457-HYD-XX-XX-DR-GE-1001

REVISION: P02

Project ID:	22457	Title:	Section Line
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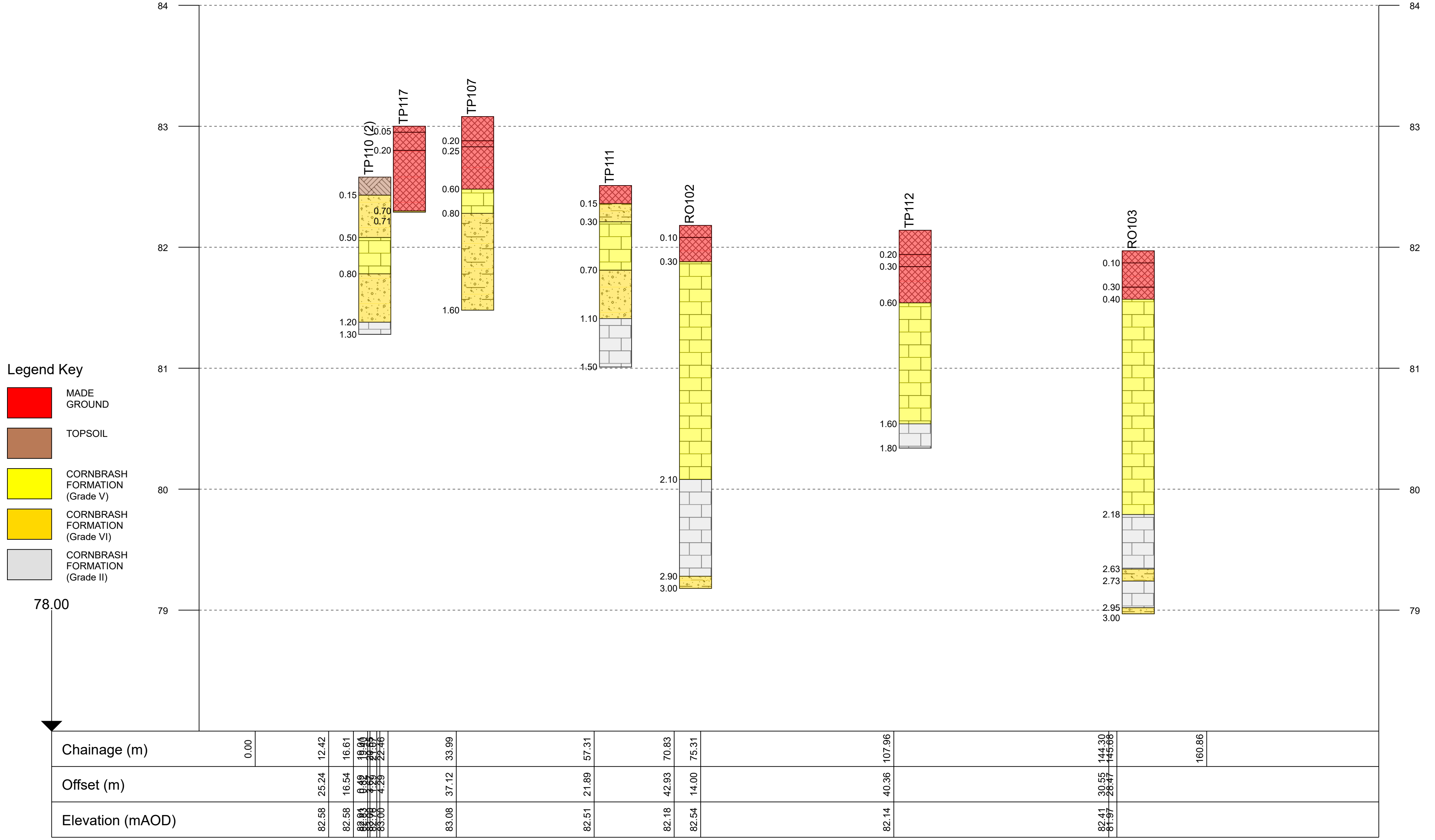
Client:	IKS Consulting Limited on behalf of Bicester Motion	Vertical Scale:	1:44



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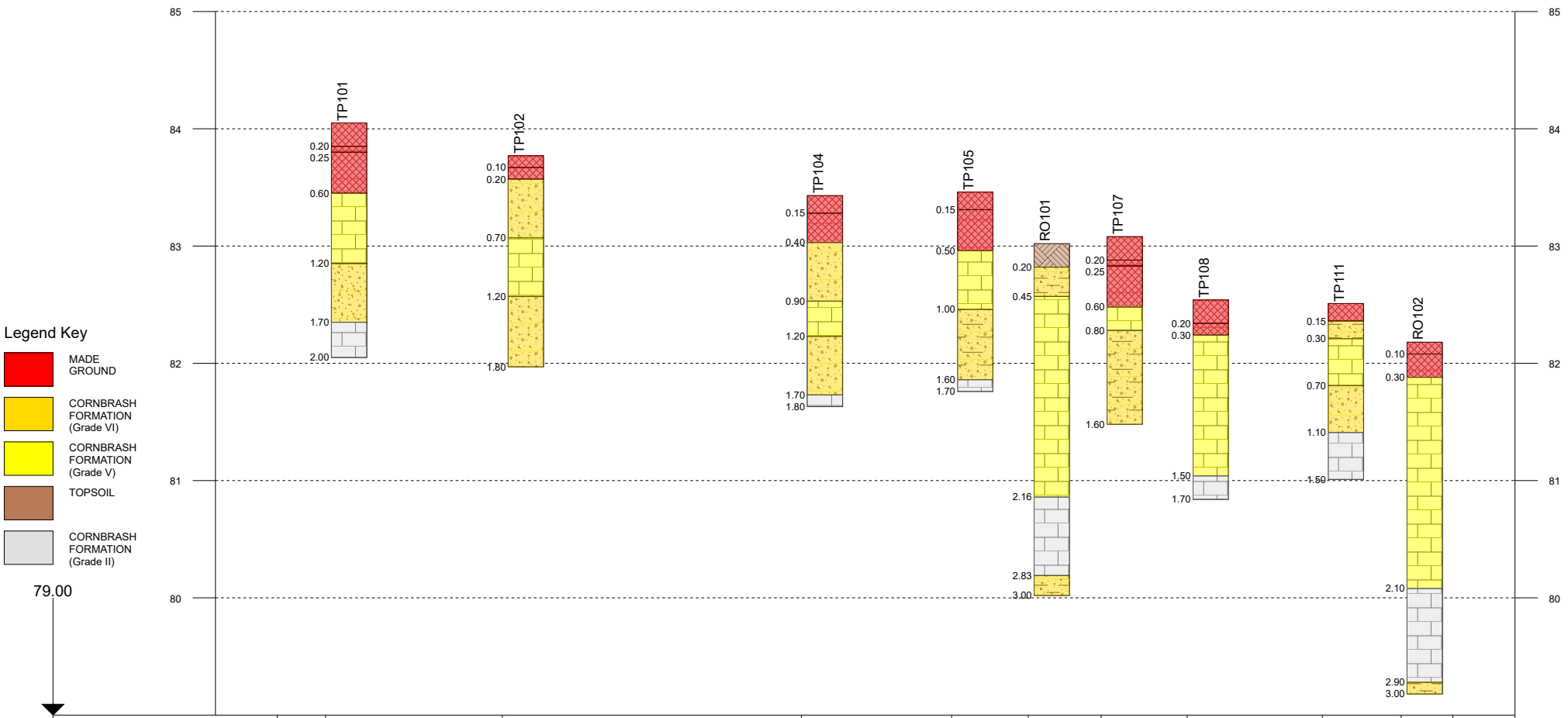
Client:	IKS Consulting Limited on behalf of Bicester Motion	Vertical Scale:	1:50



Chainage (m)	0.00	12.86	59.91	139.53	179.53	199.91	219.31	242.21	278.20	299.17	312.92
Offset (m)	9.49	15.72	4.48	21.00	17.26	25.39	16.06	1.76	11.88		
Elevation (mAOD)	84.05	83.77	83.43	83.46	83.02	83.08	82.54	82.51	82.18		

Appendix B Field Reconnaissance Photographs

Desk Study Photograph 1	
Date: 14/02/2022	
Direction Photograph Taken: North west.	
Description: Looking along section of track and area of grass.	

Desk Study Photograph 2	
Date: 14/02/2022	
Direction Photograph Taken: West.	
Description: Looking along southern boundary on left with grassland and track with parked cars on site.	

Desk Study Photograph 3	
Date: 14/02/2022	
Direction Photograph Taken: North.	
Description: Looking along section of track with grassland visible.	

Desk Study Photograph 4	
Date: 14/02/2022	
Direction Photograph Taken: East.	
Description: Looking at old pillbox.	

Desk Study Photograph 5	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Looking across area of grass with a section of track.	

Desk Study Photograph 6	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Looking across area of grass and track with building visible in background.	

Desk Study Photograph 7	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Looking across area of grass and track.	

Desk Study Photograph 8	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Looking across area of grass and track.	

Desk Study Photograph 9	
Date: 14/02/2022	
Direction Photograph Taken: South.	
Description: Looking across area of grass with Southern boundary visible in background.	

Desk Study Photograph 10	
Date: 14/02/2022	
Direction Photograph Taken: West.	
Description: Looking over area with grass and trees forming western boundary.	

Desk Study Photograph 11	
Date: 14/02/2022	
Direction Photograph Taken: West.	
Description: Looking across area of grass and trees forming western boundary.	

Desk Study Photograph 12	
Date: 14/02/2022	
Direction Photograph Taken: North West.	
Description: Looking across area of grass with Western boundary and entrance/exit gate seen in the distance.	

Desk Study Photograph 13	
Date: 14/02/2022	
Direction Photograph Taken: North West.	
Description: Entrance/exit gate leading onto A4421.	

Desk Study Photograph 14	
Date: 14/02/2022	
Direction Photograph Taken: North	
Description: Warning sign.	

Desk Study Photograph 15	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Looking across area of grass with buildings in distance beyond Southern boundary and drain cover visible in grass.	

Desk Study Photograph 16	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Drain cover.	

Desk Study Photograph 17	
Date: 14/02/2022	
Direction Photograph Taken: South.	
Description: Looking down the Western boundary consisting of trees and bushes.	

Desk Study Photograph 18	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Manhole cover.	

Desk Study Photograph 19	
Date: 14/02/2022	
Direction Photograph Taken: West.	
Description: A former and now derelict RAF bunker located along the western boundary, behind the shrubbery.	

Desk Study Photograph 20	
Date: 14/02/2022	
Direction Photograph Taken: North.	
Description: Former RAF bunker.	

Desk Study Photograph 21	
Date: 14/02/2022	
Direction Photograph Taken: North East.	
Description: Internal view of former RAF bunker.	

Desk Study Photograph 22	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Looking across area of grass with southern boundary in back ground with visible buildings and parked vehicles.	

Desk Study Photograph 23	
Date: 14/02/2022	
Direction Photograph Taken: East.	
Description: Looking over grass and vehicle track with buildings visible in background.	

Desk Study Photograph 24	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Looking over grass and vehicle track with old buildings and parked vehicles in background behind southern boundary.	

Desk Study Photograph 25	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Tree standing near old fuel tank beneath ground with grass, old buildings and parked vehicles in background.	

Desk Study Photograph 26	
Date: 14/02/2022	
Direction Photograph Taken: East.	
Description: Manhole cover leading to old fuel tank.	

Desk Study Photograph 27	
Date: 14/02/2022	
Direction Photograph Taken: South East.	
Description: Another manhole cover leading to old fuel tank found by tree.	

Desk Study Photograph 28	
Date: 14/02/2022	
Direction Photograph Taken: N/A.	
Description: Close up of fuel tank manhole covers.	

Desk Study Photograph 29	
Date: 14/02/2022	
Direction Photograph Taken: North.	
Description: Looking over area of grass and vehicle track.	

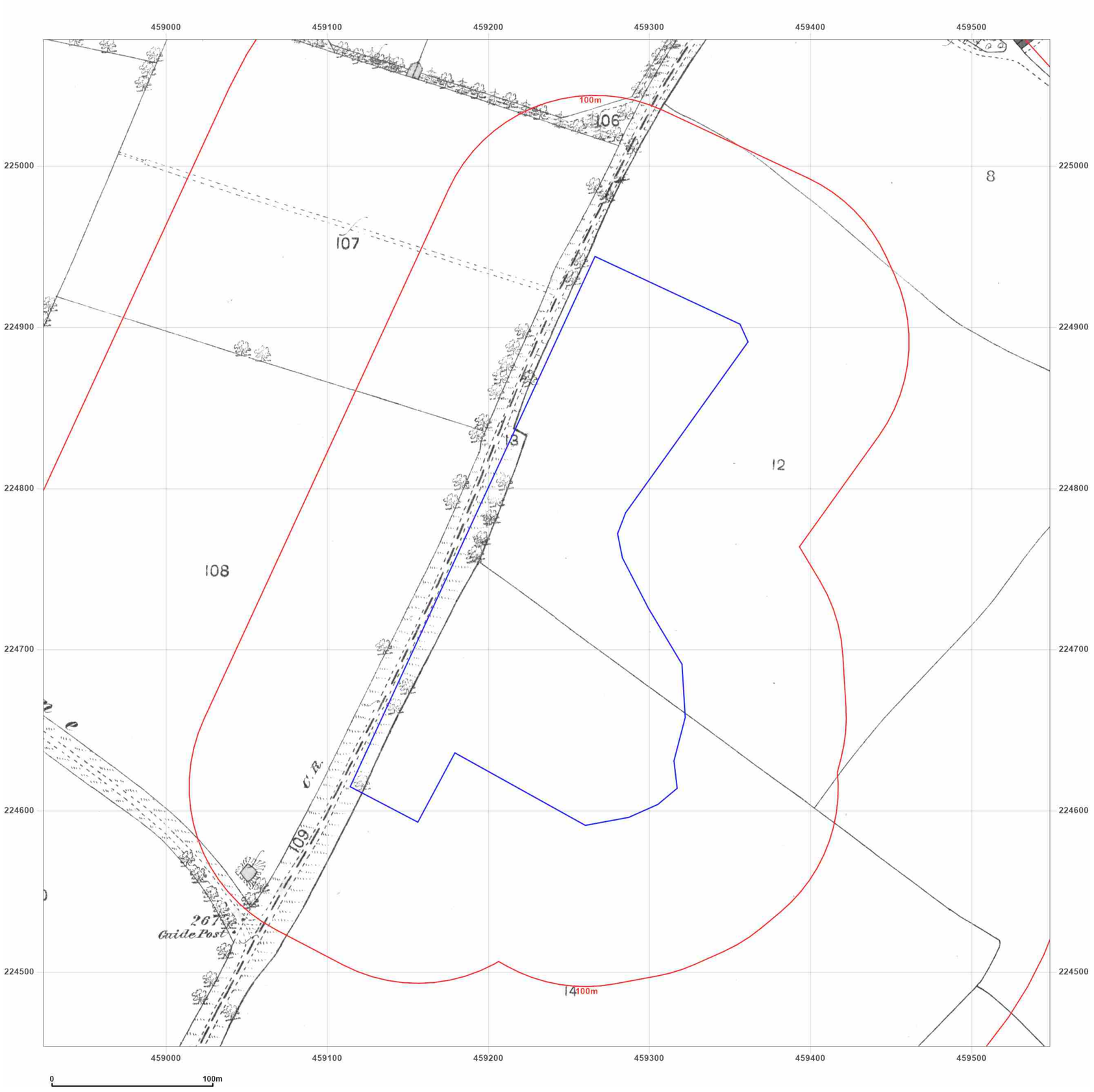
Desk Study Photograph 30	
Date: 14/02/2022	
Direction Photograph Taken: North East.	
Description: Looking over grass and vehicle track with building in background.	

Desk Study Photograph 31	
Date: 14/02/2022	
Direction Photograph Taken: South west.	
Description: Small electrical substation in background with old control box in foreground.	

Desk Study Photograph 32	
Date: 14/02/2022	
Direction Photograph Taken: West.	
Description: Old control box.	

Desk Study Photograph 33	
Date: 14/02/2022	
Direction Photograph Taken: South West.	
Description: Small electrical substation.	

Appendix C Historical Ordnance Survey Maps



Groundsure INSIGHTS

Site Details:

459250, 224697

Client Ref: 22457-GMNO
Report Ref: GS-8608302_2500
Grid Ref: 459236, 224766

Map Name: County Series

Map date: **1881**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1881
Revised 1881
Edition N/A
Copyright N/A
Levelled N/A

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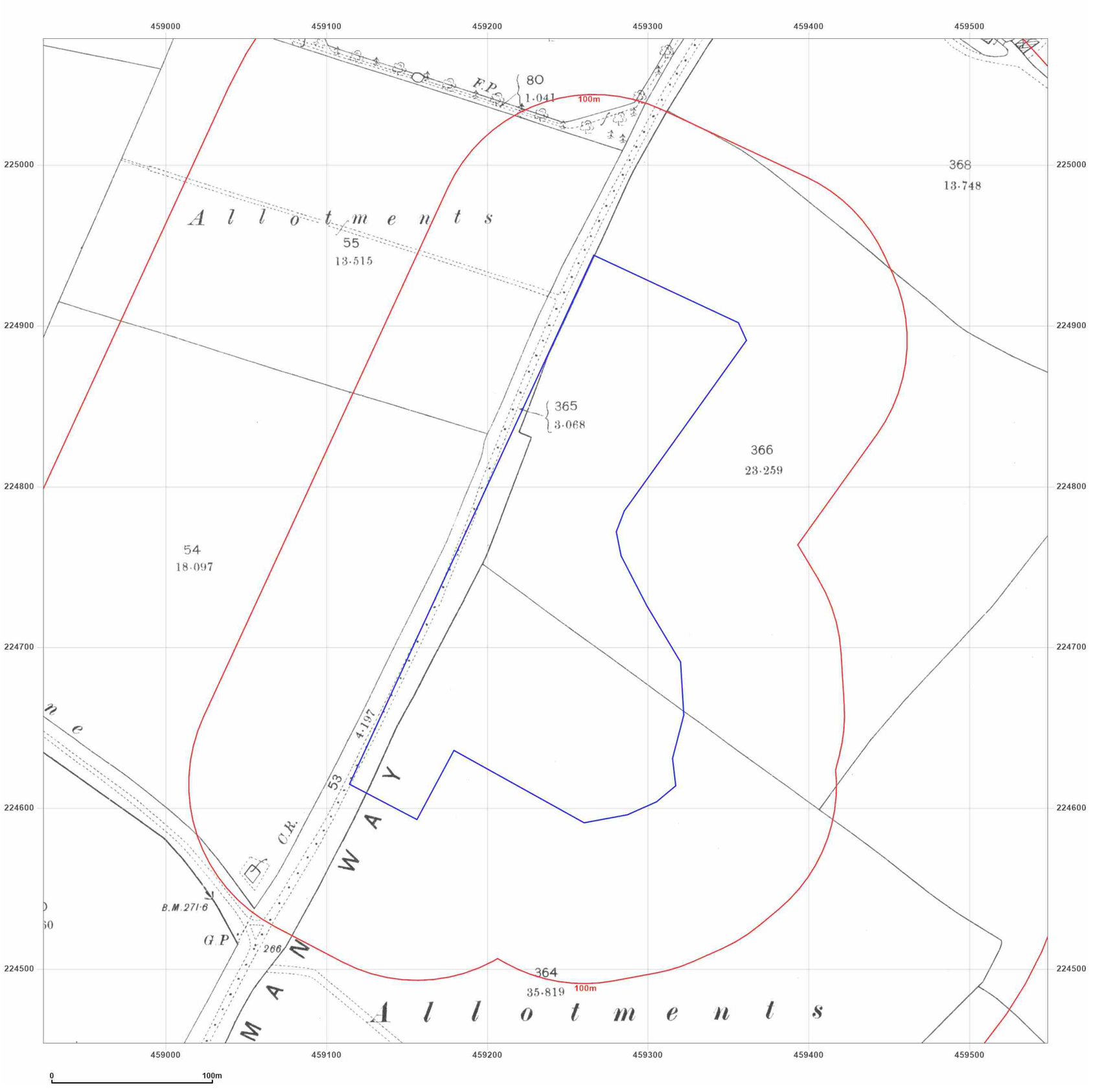
Produced by
Groundsure Insights
T: 08444 159000
E: info@groundsure.com
W: www.groundsure.com

Production date: 21 March 2022

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf



Groundsure INSIGHTS

Site Details:

459250, 224697

Client Ref: 22457-GMNO
Report Ref: GS-8608302_2500
Grid Ref: 459236, 224766

Map Name: County Series

Map date: **1899**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1899
Revised 1899
Edition N/A
Copyright N/A
Levelled N/A

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W: www.groundsure.com

Production date: 21 March 2022

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf

Groundsure INSIGHTS

Site Details:

459250, 224697

Client Ref: 22457-GMNO
Report Ref: GS-8608302_2500
Grid Ref: 459236, 224766

Map Name: County Series

Map date: **1922**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1922
Revised 1922
Edition N/A
Copyright N/A
Levelled N/A

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Production date: 21 March 2022

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf

Groundsure INSIGHTS

Site Details:

459250, 224697

Client Ref: 22457-GMNO
Report Ref: GS-8608302_2500
Grid Ref: 459236, 224766

Map Name: National Grid

Map date: **1968**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
S

Surveyed 1966
Revised 1966
Edition N/A
Copyright 1968
Levelled 1962

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Map legend available at:
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