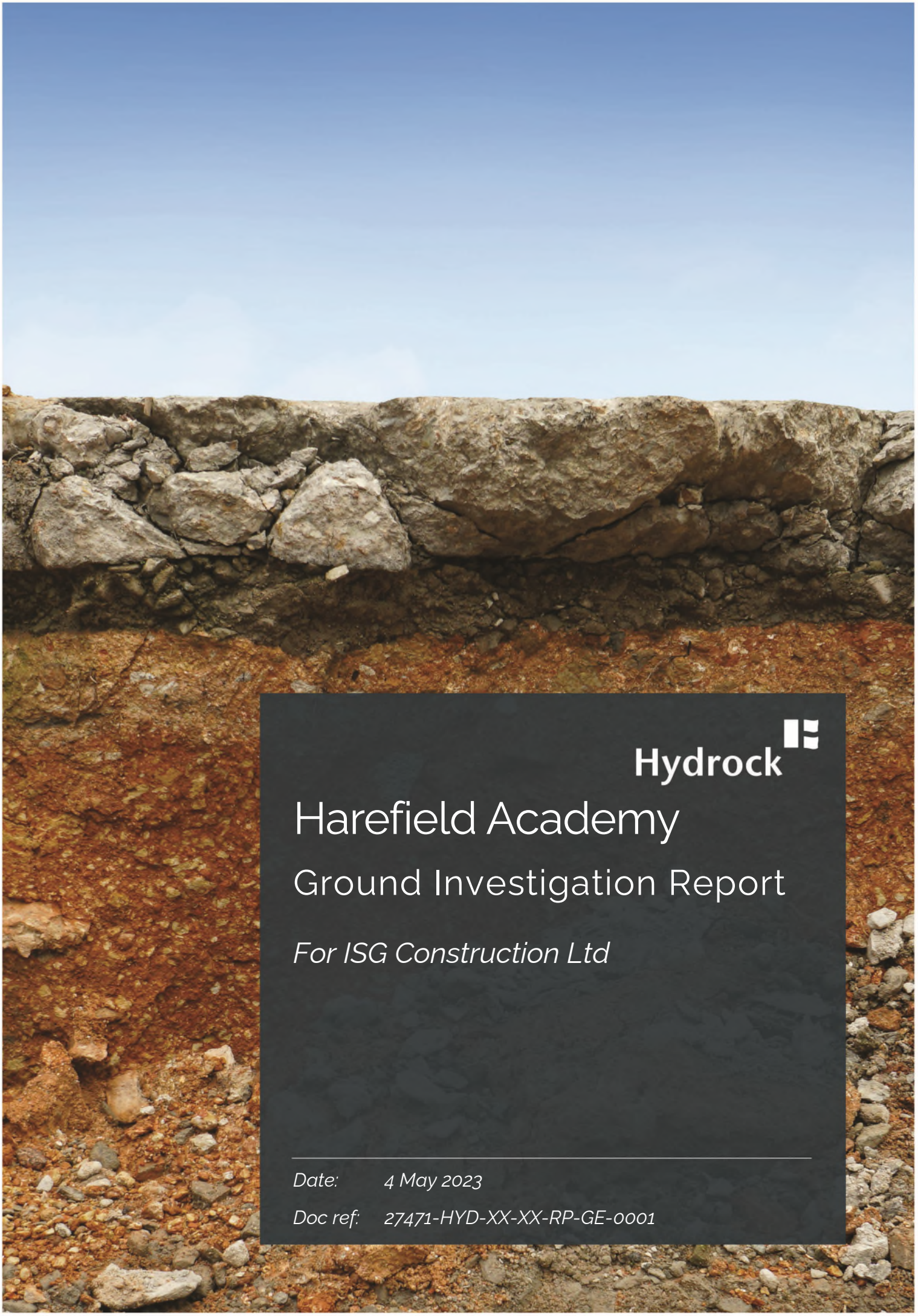

Hydrock

Harefield Academy

Ground Investigation Report

For ISG Construction Ltd

Date: *4 May 2023*

Doc ref: *27471-HYD-XX-XX-RP-GE-0001*

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Executive summary

Site information and setting	
Objectives	Phase 1 Desk study to; » Formulate a preliminary initial Conceptual Site Model and make preliminary assessment of geo-environmental and geotechnical risks. Phase 2 Site Investigation to; » Resolve any geo-environmental and geotechnical uncertainties; » Identify geo-environmental mitigation requirements To provide preliminary geotechnical recommendations for design.
Client	ISG Construction Ltd
Site name and location	Harefield Academy, Northwood Way, Harefield, Uxbridge, UB9 6ET.
Proposed development	The site has been acquired to be extended and refurbished, and used as a school.
Site description	The site is approximately triangular in shape and has an area of approximately 0.2 ha. The investigation area is bound to the northwest by the existing school building and multi-use games area. To the northeast is a residential property and to the south the site is bound by Northwood Road with a residential area beyond. Currently the investigation area is occupied by some areas of soft landscaping with trees, adjacent to the Adonis House existing building, a service road for school deliveries, a multi-use games area and an area of hardstanding in east corner of the site which holds a few storage containers.
Desk study summary	
Topography	The site and surrounding area is generally flat and is typically 87 to 88m above Ordnance Datum.
Hydrology	The site has inland rivers located, 78m north, 95m north-west and 130m north-west.
Site History	Earliest maps show the site as agricultural land from 1865 to at least 1913. From 1934 to around 1955 the site was used as an allotment garden. From 1955 the site is part of school grounds and undergone multiple phases of development and remains a school to the present day.
Geology	Superficial: Gerrards Cross Gravels Solid: London Clay Formation
Natural geological hazards	Potential for soft ground in London clay geology. The London Clay Formation is often sulphate bearing and may affect concrete below ground. Low or negligible risk from slope stability, running sands, solution features or cambered ground.

Anthropomorphic geotechnical hazards	Potential for Made Ground at the site from development activity over time.
Hydrogeology	Gerrards Cross Gravels are a Secondary A aquifer. The site also lies within a Source Protection Zone 2 (SPZ2) with a potable water abstraction 852m west of the site (abstraction from the Chalk aquifer).
Site zoning	For the purpose of this report the site has been considered as a single zone.
UXO risk	A non-specialist UXO assessment indicates a low risk with regard to UXO and no further assessment is required in relation to ground investigation.
Preliminary conceptual site model based on desk study	
Potential contaminant sources	The potential sources of contamination for the whole site are as follows: » Made Ground, associated with historical construction activities and imported fill, possibly including elevated concentrations of metals, metalloids, asbestos fibres, Asbestos Containing Materials, polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons (S01). » Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former school buildings (S02). » Coal tar, potentially present in the bituminous bound pavements present in the form or roads or hardstanding. (S03). » Ground gases (carbon dioxide and methane) from organic materials in the Made Ground (S04).
Potential contaminant linkages (for receptors for which there is or will be a pathway)	Humans - for the purpose of this report the site has been assessed under a scenario of residential without plant uptake. Controlled waters - Potential of leaching from Made Ground into Secondary A aquifer (Gerrards Cross Gravels)
Ground model proven by investigation	
Ground and groundwater conditions encountered by investigation	The ground conditions as proven by the investigation undertaken at the site comprise: » Made Ground – between GL and 0.50m below ground level (bgl), comprising grey to brown gravelly and/or sandy CLAY. Gravel is fine to coarse, angular to subangular brick and flint. » Gerrards Cross Gravels – between 0.70m and 1.80m bgl, comprising orange to brown slightly silty SAND and GRAVEL, Gravel is fine to coarse rounded to subangular flint and quartz. » Weathered London Clay Formation - between 1.00 and 4.50mbgl, comprising firm mottled orangish brown CLAY. » London Clay Formation – between 1.00m and to at least 15.00m bgl (base unproven), comprising firm to stiff dark greyish brown CLAY. Groundwater was not encountered during the intrusive investigation, however water levels recorded post-fieldwork ranged from 0.37m bgl to 0.81m bgl (86.06m OD to 85.11m OD) in the Made Ground and Gerrards Cross Gravels. The shallow groundwater may have been affected by leaking services on site.

Summary of geotechnical conclusions	
Groundwork	Obstructions associated with current development, including foundations, Made Ground and services should be anticipated. Excavation to proposed founding depth generally should be readily achievable with standard excavation plant. Heavy duty excavation plant/breaking equipment may be required to break out obstructions in the ground. Excavations during investigation were generally stable, although slight spalling should be expected from the Made Ground and within the sands and gravels. Water seepages into excavations are likely to be adequately controlled by sump pumping.
Foundations	Foundations are recommended to comprise piled foundations. Piles should extend through the Made Ground and Gerrards Cross Gravels to a suitable depth into the underlying London Clay Formation. Continuous Flight Auger (CFA) piles are expected to be the most appropriate piling methodology. However, the choice of piling system should be by a specialist piling Contractor and the design of piles is beyond the scope of this report. Heave protection is required on the inside faces and underside of the ground beams and void is required below the floor slab.
Sustainable drainage	Soakaway drainage is considered unsuitable for this site.
Buried concrete	Design Sulfate Class - DS-4 and ACEC Class AC-4.
Summary of geo-environmental assessment	
Human Health	One exceedance of GAC in soils of Dibenz(ah)anthracene. This exceedance is not considered an unacceptable risk to human health and no further consideration is required.
Controlled waters	The concentrations of cadmium, cobalt, copper, cobalt, manganese, nickel, ammoniacal nitrogen and sulphate in groundwater slightly exceed the assessment criteria. Concentrations of petroleum hydrocarbons were not recorded above the limit of detection. The investigation in the area noted very little in the way of definite sources which may have contributed to these exceedances, and it is considered probable that the levels recorded are in line with background levels in the area. On this basis Hydrock believes that the risks to Controlled Waters do not need further consideration.
Radon:	BR211 indicates the site is in a low radon area and no radon protection is required.
Construction materials:	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.
Potable water supply pipes	Standard pipework is envisaged. However, confirmation should be sought from the water supply company at the earliest opportunity.
Ground gases or vapours:	Based on the recent data, ground gas protection measures are not considered necessary for the extension. This will be confirmed following the final 3 post-fieldwork monitoring visits. As such, no ground gas protection is currently proposed, however this will be confirmed in an updated version of this report following completion of the post-fieldwork monitoring.

Enabling works	
Proposed mitigation measures	Dust suppression in case of works generating a significant quantity of dust. (PL1) An asbestos management plan to be in place in the event of discovery of asbestos in the Made Ground soils to ensure safety of site staff and to ensure works are carried out in accordance with CAR 2012. (PL2) It is understood that ground gas protection measures are present within the existing building, therefore consideration will need to be given to tying in the foundations of the extension with the existing building.
Waste management	The site is brownfield and based on the site history, laboratory 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 they are likely to be classified as non-hazardous waste.
Future considerations	
Further work	Following the ground investigation works undertaken to date, the following further works will be required: » completion and reporting of the ongoing gas monitoring, hence the conclusions in this report are provisional, subject to the completion of monitoring; » discussion and agreement with utility providers regarding the materials suitable for pipework; » discussions with regulatory bodies and the warranty provider regarding the conclusions of this report; » assessment of tree influence on foundations and design of foundations; » discussions with piling Contractors regarding conclusions of this report and design of the piles; » provision of geotechnical design for the structure (piled foundations); » production of a Materials Management Plan relating to reuse of soils at the site and import of soils to the site (if required); » writing of a Materials Management Strategy relating to reuse of soils at the site (if required); » writing of a Discovery Strategy, as a full Remediation Strategy and Verification Report is not required based on the findings of this report; » mitigation works; and » verification of the mitigation works.

This Executive Summary forms part of Hydrock Consultants Limited report number 27471-HYD-XX-XX-RP-GE-0001 and should not be used as a separate document.

1. Introduction

1.1 Terms of reference

In March 2023, Hydrock Consultants Limited (Hydrock) was commissioned by ISG Construction Ltd (the Client) to undertake site investigation, comprising a Phase 1 desk study and Phase 2 ground investigation at Harefield Academy. The site is located at Northwood Way, Harefield, Uxbridge, UB9 6ET.

The site is currently a former school building with external landscaped area which is currently unused.

Hydrock understands that the site has been acquired to be extended and refurbished and once again used as a school. A proposed development layout (drawing 4266-CDC-XX-00-DR-A-001 Rev E), is presented in **Appendix A**. The proposed development consists of three storey extension to the existing building.

The investigation works have been undertaken in accordance with Hydrock's proposal (ref: 27471-HYD-XX-XX-FP-GE-0001, dated 10th February) and the Client's instructions to proceed.

1.2 Objectives

The works have been commissioned to assist with the design of the development.

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

The objectives of the Phase 2 Ground Investigation are:

- to resolve any geotechnical and geo-environmental uncertainties identified in the Phase 1 Desk Study by refining and updating the preliminary Ground Model, based on the conditions met in accordance with the principles of Environment Agency (EA) 'Land Contamination: Risk Management' (LCRM) (2020);
- to identify any geo-environmental mitigation requirements to enable development to progress; and
- to provide preliminary geotechnical recommendations for design.

1.3 Scope

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

The scope of the Phase 1 Desk Study comprises:

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

- development of an initial Conceptual Site Model (iCSM), including identification of potential contaminant linkages;
- a qualitative assessment of any geo-environmental risks identified; and
- identification of any plausible geotechnical hazards.

The scope of the Phase 2 Ground Investigation comprises:

- a ground investigation including trial pitting, windowless sampling, dynamic probing and cable percussive boring to:
  - obtain data on the ground and groundwater conditions of the site;
  - allow collection of samples for geotechnical and chemical laboratory analysis;
  - allow geotechnical field tests to be undertaken;
  - install gas and groundwater wells;
- gas concentration and groundwater level monitoring;
- 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 any plausible contaminant linkages;
- completion of a generic quantitative risk assessment of any identified chemical contaminants to establish 'suitability for use' under the current planning regime;
- discussion of any potential environmental liabilities associated with land contamination (soil, water and gas); and
- identification of outline mitigation requirements to ensure the site is 'suitable for use'.

1.4 Available information

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

- Ian Farmer Associates Ground Investigation Report, November 2022. Adonis House, The Harefield Academy, Contract: 2240649.

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

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, BS 10175:2011+A2:2017 and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

The geo-environmental section of this report is written in broad accordance with BS 10175:2011+A2:2017, EA LCRM), (2021) and the AGS (2006) 'Good Practice Guidelines for Site Investigations'.

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

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

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

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

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

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

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

2. Desk study (and field reconnaissance)

2.1 Data

A number of desk study sources have been used to assemble the following information. These are presented in **Appendix B** and **Appendix C** and include:

- Third-party environmental report (Groundsure, reference HYD-9412163);
- Historical Ordnance Survey mapping;
- BGS Archive Records; and
- Zetica UXB Risk Maps (https://zeticauxo.com/downloads-and-resources/risk-maps/).

As part of the desk study information, a previous ground investigation undertaken at the site has been reviewed (see Section 1.4). Where suitable (see Section 1.4), the data from the previously referenced reports is included within this desk study. Previous information includes:

- Ian Farmer Associates Ground Investigation Report, November 2022. Adonis House, The Harefield Academy, Contract: 2240649.

2.2 Site referencing

Table 2-1: Site referencing information

Item	Brief Description
Site name	Harefield Academy
Site address	Northwood, Way, Harefield, Uxbridge, UB9 6ET
Site location and grid reference	The site is located East of the town of Harefield off of Northwood Road. The National Grid Reference of the approximate centre of the site is 505934E, 190816N. The site is approximately 0.2 Ha in area and measures approximately 200 x 40m.
Site boundaries	The investigation area is bound to the northwest by the former school building and multi-use games area. To the north east is a residential property and to the south the site is bound by Northwood Road with a residential area beyond.

Figure 2.1: Site location (Reproduced with permission from Groundsure)

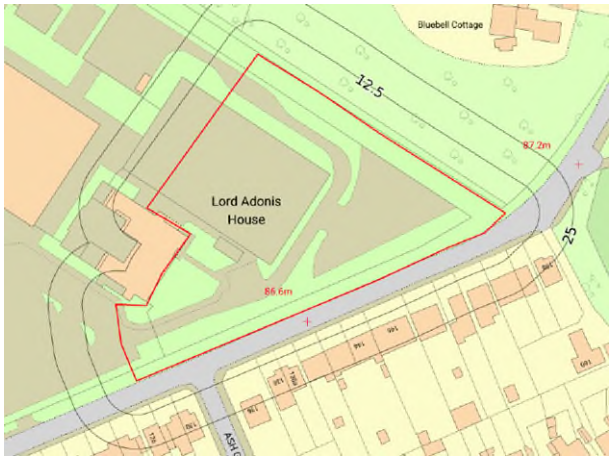


Figure 2.2: Extract from the Ordnance Survey Map. (OS licence 100023353).

A site location plan (Hydrock Drawing 27471-HYD-XX-XX-DR-GE-0001) is presented in **Appendix A**.

2.3 Site description and field reconnaissance survey

A field reconnaissance survey was undertaken on Tuesday 14th March to visually identify assess potential geotechnical hazards, contaminant sources for investigation and identification of possible source-pathway-receptor linkages. The weather during the field reconnaissance survey was cloudy.

A description of the site is presented in Table 2-2.

Table 2-2: Site description

Item	Brief Description
Site access	The School was accessed by the main gate on Northwood Way. The site area was accessed by the gate at the east of the car park.
Site area	The site is approximately triangular in shape and has an area of approximately 0.2 ha.
Elevation, topography and any geomorphic features	The site and surrounding area is generally flat and is typically 87 to 88m above Ordnance Datum.
Site boundaries and surrounding land	To the north-west the site is bound by The Harefield Academy. North-east of the site is a residential property and to the south the site is bound by Northwood Road and beyond is a residential area.
Present land use	Currently the investigation area is occupied by some areas of soft landscaping adjacent to the Adonis House building, a service road for school deliveries, a multi-use games area and an area of hardstanding in east corner of the site which holds a few storage containers.

	There is also a bio-mass boiler located between the area of soft landscaping and the multi-use games area.
Vegetation	The school boundaries within the investigation area are vegetated with shrubbery. The remainder of the vegetated areas were grass covered.
General site sensitivity	The site sits on the border of a residential area to the south and west and green belt land to the north and east. There are 3 areas of ancient woodland within 500m of the site, located 263m to the north (Pearsons Wood), 332m to the south (Asham Spring Wood) and 492m to the south (Clay Pits Wood).

2.4 Site history

A study of historical Ordnance Survey maps (**Appendix B**) has been undertaken to identify any former land uses at the site and surrounding areas which may have geotechnical or geo-environmental implications for the proposed development. The key findings are summarised in Table 2-3.

Table 2-3: Site history review

Reference	Key features on site	Key features off-site
OS Map[1] 1865 - 1913: 1:10,560	Earliest maps show the site to have been used as agricultural land from 1865 through to 1913.	The site is surrounded by a mix of agricultural and woodland, Approximately 200m is Shepherdshill Farm, with the town of Harefield located 500m to the south west.
OS Map 1934: 1:10,560	The site area is now shown on the maps as an allotment garden.	Expansion of the town of Harefield including the construction of a sanatorium and many residential properties including the houses opposite the site area on Northwood Way and more homes north-east of site.
OS Map 1955 – 1976 1:10;560	The site now forms part of Harefield Secondary School (also identified as 'John Penrose School' on some maps) and the site area is assumed to be playing fields.	The school buildings are constructed immediately to the west of the site area with one main building and a number of smaller buildings around it. Further development continues in Harefield town with more residential development continuing to the west and south of the site and the new Harefield Reservoir approximately 800m north-east of site.
OS Map 1987 – 1989 1:10;000 & 1989 - 1992 1:2500	Expansion at the school includes the extension of the main school building to just inside the site boundary in the south eastern corner of the site.	Extension of the school buildings.

[1] Ordnance Survey Historical Map Information provided by Groundsure

OS Map 2010 – 2023 1:10,000	Demolition of the building which extended into the south eastern corner of the site.	The school has undergone further development including the demolition of some buildings and construction of the site as it is seen presently.

2.5 Geology

The geology of the site area is shown on the British Geological Survey (BGS) 1:50,000 geological map of Beaconsfield (Sheet 255) and is summarised below:

Table 2-4: Geology

Ref. for Figures	Location	Stratigraphic Name	Description
Superficial Deposits (Figure 2.3)			
1	On site	Gerrards Cross Gravel	1 - 10m of sand and gravel, locally with lenses of silt, clay, peat and organic material.
Solid Geology (Figure 2.4)			
1	On site.	London Clay Formation	The London Clay Formation mainly comprises blue-grey or grey-brown, often silty, clay.
2	278m north	Lambeth Group	Variable sequences of sometimes silty and sandy clay with some sand and gravels.

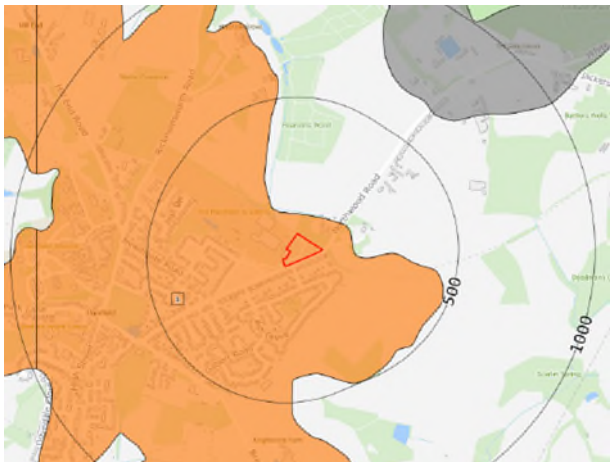


Figure 2.3: Superficial deposits. (Reproduced with permission from Groundsure)

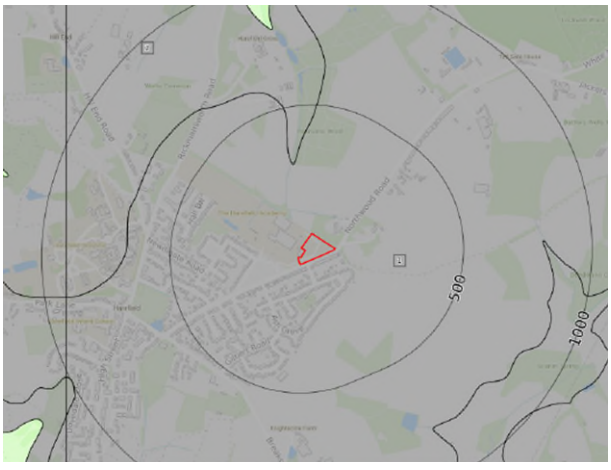


Figure 2.4: Solid geology. (Reproduced with permission from Groundsure)

There are few BGS archive records in the immediate area of the site. The nearest available borehole log from the BGS archive has been reviewed (TQ09SE31). This record is summarised below:

» TQ09SE31 located 900m to the south-west of the site near Lewis Close (NGR 505200E, 190300N), drilled to a depth of 20m and recorded:

- Brown, sandy, clayey silt with some rounded gravel and abundant recent roots between ground level and 0.50m below ground level (bgl);
- Dense brown to light brown sandy, silty clayey GRAVEL. between 0.50 and 4.60m bgl;
- Firm brown and light brown silty CLAY between 4.60m and 7.50m bgl;
- Very stiff fissured grey silty CLAY between 7.50m and 20.00m bgl.

The ground conditions proven by previous investigation (Ian Farmer Associates Ground Investigation Report, November 2022. Adonis House, The Harefield Academy, Contract: 2240649), comprise:

- Made Ground - Soft brown mottled grey slightly gravelly sandy CLAY between ground level and 1.50m bgl;
- Gerrards Cross Gravel - Very dense orange brown clayey fine to coarse SAND and GRAVEL between 1.50m and 3.40m bgl.;
- London Clay formation - Firm brown CLAY becoming stiff fissured grey CLAY between 3.40m and 10.00m bgl.

2.6 Hydrogeology

2.6.1 Aquifer designations

Based on the inferred geological sequence presented in Section 0 and the Environment Agency's interactive aquifer designation map, the aquifer system presented in Table 2-5 applies. Additional information on the hydraulic characteristics of the geological units has been abstracted from Allen et al (1997).

Table 2-5: Aquifer system

Stratum	Aquifer Designation	Comments
Superficial Deposits		
Gerrards Cross Gravel	Secondary A aquifer	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
Solid Geology		
London Clay Formation	Unproductive	Dominated by low permeability and low porosity clay, the London Clay is of negligible significance for water supply of river base flow.

2.6.2 Groundwater abstraction

There is one active licensed groundwater abstractions within 1000m of the site, shown in Table 2-6. Based on available BGS records, this abstraction is from the Chalk (water well reference TQ09/132).

Table 2-6: Groundwater abstractions

Location Relative to Site	Purpose of Abstraction
852m West	Potable/Industrial - For Harefield Hospital

2.6.3 Groundwater source protection zones and groundwater vulnerability

The site is mostly within a Zone 2 (Outer) groundwater Source Protection Zone (SPZ2), with the northeast corner within a Zone 3 (Total) SPZ – see Figure 2.5. The SPZ is understood to be related to the Chalk (Principal aquifer located at depth on site).

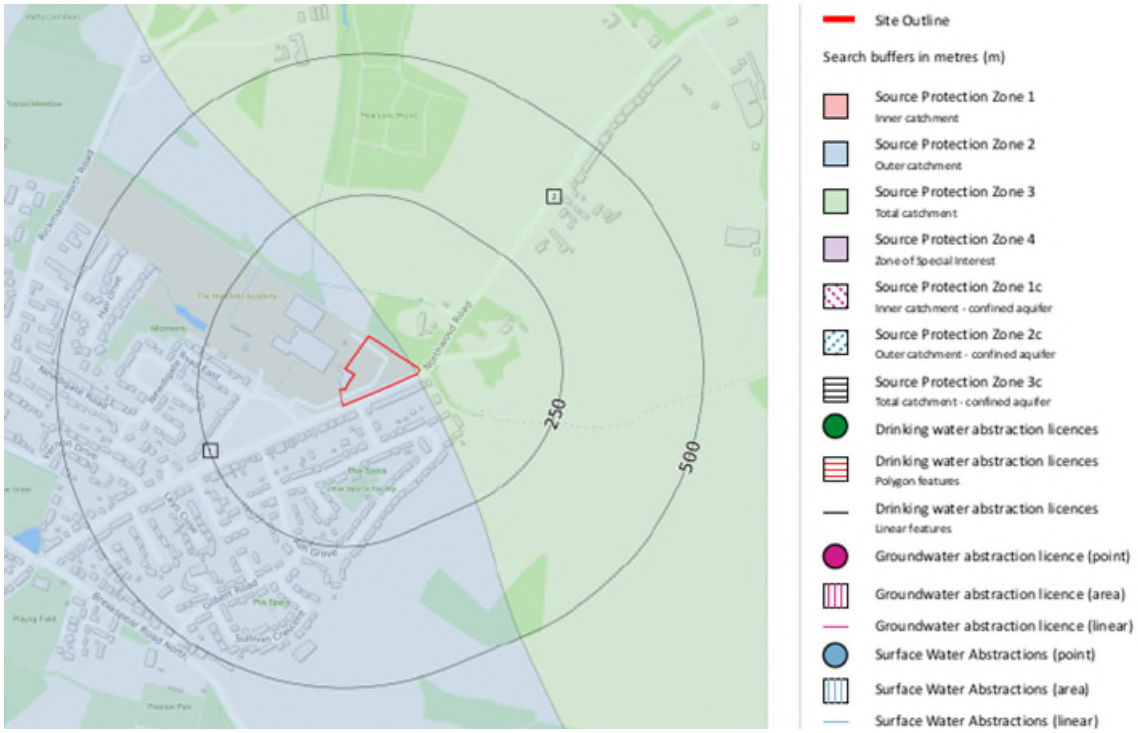


Figure 2.5: Groundwater Source Protection Zones (SPZ's) (Reproduced with permission from Groundsure)

2.6.4 Groundwater levels, recharge, and flow

Information from the BGS Hydrogeological Maps and supporting data from BGS historical boreholes indicate groundwater levels in the Chalk (Principal aquifer) are likely to be in excess of 20m bgl. The London Clay Formation acts as an aquiclude. Therefore, there is not considered to be a pathway to groundwater within the Chalk. As such, the risk to the Principal aquifer is not considered any further within this report.

Shallow groundwater is likely to be present within the Gerrards Cross Gravel, with a deeper groundwater body in the Upper Chalk. The presence of the low permeability London Clay Formation will inhibit vertical connection between these two groundwater bodies.

Recharge to the Gerrards Cross Gravels and Made Ground would be expected to take place locally.

Groundwater was recorded at 2.60m bgl (85.1m OD) in available BGS borehole data (for borehole TQ09SE31 located 900m to the south-west of the site at Lewis Close).

During the previous ground investigation (Ian Farmer Associates, 2022) groundwater seepages were recorded as follows:

» Seepage in the Made Ground at TP3, TP5 and TP6 at depths of between 0.76 and 1.00m bgl.

Post-fieldwork monitoring also identified groundwater present at a depth of 1.52m bgl within the Gerrards Cross Gravels.

Shallow groundwater below the site is likely to drain towards the inland river, approximately 100m north of the site. However, the often silty/clayey nature of the Gerrards Cross Gravel may impede vertical and lateral groundwater flow.

2.6.5 *Groundwater quality*

The site area is not located within a known groundwater body catchment area.

2.6.6 *Groundwater flooding*

The environmental data report indicates a low risk of groundwater flooding.

2.7 Hydrology

2.7.1 *Surface water system and drainage*

The surface water features in the vicinity of the site are listed in Table 2-7.

Table 2-7: Surface water features

Feature	Location Relative to Site
Surface water drainage system	On-Site
Inland river	78m North
Inland river	95m North-west
Inland river	130m North-west

2.7.2 *Surface water abstractions and discharges*

There are no active surface water abstractions or discharges within 1km of the site.

2.7.3 *Surface water quality*

Reference to the Environment Agency web site shows the site is located within the catchment known as the Colne Operational Catchment. The specific river water body being the Colne (Confluence with Chess to River Thames) Water Body. The current (2019 cycle 3) status under the Water Framework Directive is described as 'moderate' for ecological and 'fail' for chemical.

The reason for the water body currently having a 'moderate' ecological status is due to;

- Moderate biological quality elements, physico-chemical quality elements, and supporting elements;
- High specific pollutants including; Arsenic, Copper, Iron, Manganese, Permethrin, Triclosan and Zinc.

The reason for having a 'fail' chemical status is due to;

- Fail of perfluorooctane sulphonate (PFOS) and polybrominated diphenyl ethers (PBDE).

2.7.4 *Surface water flooding*

The desk study information indicates the proposed development is in Flood Zone 1 with a low probability of flooding from rivers or the sea with a negligible risk of surface water flooding.

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

2.8 Waste management

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

2.9 Regulatory Information

Information in the environmental report (**Appendix C**), relating to various regulatory controls has been reviewed, with a summary presented below in Table 2-8.

Table 2-8: Regulatory information within 500m of the site

Regulatory Data	Distance from Site	Details	Potential Risk	Comment
Electrical sub station	128m North-west 159m West 160m South-west	Electricity sub station	No	Due to its proximity to the site.

2.10 Natural soil chemistry

Information contained within the environmental report (**Appendix C**) gives indicative (estimated) concentration values for the natural soils at the site for a selection of Contaminants of Potential Concern (CoPC). These have been reproduced in Table 2-9.

Table 2-9: Natural soil chemistry

Element	Arsenic	Cadmium	Chromium	Lead	Nickel
Concentration (mg/kg)	10-11	0.6	58-62	67	13

The data in Table 2-9 is considered within the geo-environmental assessment.

2.11 Radon

The radon risk is reported in the environmental report.

The guidance indicates that the site is not in a Radon Affected Area and no radon protection measures are required.

2.12 Unexploded ordnance (UXO)

In general accordance with CIRIA Report C681 (Stone et al 2009) a non-specialist UXO screening exercise has been undertaken for the purposes of ground investigation and is presented in Table 2-10.

Table 2-10: Non-specialist UXO screening (for the purposes of ground investigation)

Data	Comment	Further Assessment Required
Site History	There is no indication of former military use from the desk study.	No

Post War Development	Historical maps show now evidence of 'ruins' post war.	No
Geology Type	Superficial geology of dense gravels over London Clay Formation, there is potential that UXO if present would remain undetected.	Yes
Surface Cover during WWI	The surface cover during WWII 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 C** indicates the site to be in an area where the bomb risk is very low	No

The non-specialist UXO screening exercise has indicated no further assessment is required with regard to UXO in relation to ground investigation. Further assessment may be considered prudent for construction activities.

3. Initial conceptual site model

3.1 Introduction

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

3.2 Ground model

The preliminary ground model presented in 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 documents HE-DMRB-G CS 641 and CD 622.

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

3.3.2 Plausible geotechnical hazards

Plausible geotechnical hazards identified at the site are:

- Uncontrolled Made Ground (variable strength and compressibility).
- Soft / loose compressible ground (low strength and high settlement potential).
- Shrinkage / swelling of the clay fraction of soils under the influence of vegetation.
- Attack of buried concrete by aggressive ground conditions.
- Obstructions.
- Existing below ground structures to remain (Foundations and buried services.)
- Shallow groundwater.

3.3.3 Potential development elements affected

Development elements potentially affected by geotechnical hazards are:

- Buildings – foundations.
- Buildings – floor slabs.
- Roads and pavements.
- Services.
- Construction staff, vehicles and plant operators.
- Concrete below ground.

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

The above plausible geotechnical hazards and development elements affected have been carried forward for investigation and assessment. The investigation is presented in Section 5 and the assessment is presented in Section 1.

3.4 Geo-environmental exposure model

3.4.1 Context

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

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

3.4.2 Potential contaminants

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, polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons (S01).
- Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former school buildings (S02).
- Coal tar, potentially present in the bituminous bound pavements present in the form or roads or hardstanding. (S03).
- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground (S04).

3.4.2.2 Potential off-site sources of contamination

No potential off-site sources of contamination have been identified.

3.4.3 Potential receptors

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

- People (neighbours, site end users) (R01).
- Groundwater: Secondary A aquifer status of the Gerrard Cross Gravels (R02).

3.4.4 Potential pathways

The following potential pathways have been identified.

- Ingestion, skin contact, inhalation of dust and outdoor air by people (P01).
- Methane ingress via permeable soils and/or construction gaps (P02).
- Root uptake by plant (P03).
- Migration of contaminant via leachate migration through the unsaturated zone in the Gerrards Cross Gravels (P04).

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

The above sources, pathways and receptors have been considered as part of the Preliminary Risk Assessment in accordance with LCRM (2021), are considered to be plausible in the context of this site and have been carried forward for investigation and assessment. The investigation is presented in Sections 4 and 5 and the assessment is presented in Section 7. An assessment of the Source – Pathway – Receptor linkages is undertaken following the assessment (Section 7) and is presented in **Appendix J** (Table J.1).

3.4.5 *Potential implications of climate change*

Climate change has the potential to change the risk profile for conceptual site models and associated contaminant linkages. The impact of climate change on the CSM is site-specific, and a qualitative assessment of the potential impact of climate change on the CSM for this site is summarised below. The assessment has primarily utilised the guidance in Environment Agency (2010)[2] and SoBRA (2022)[3] which set out the UK context to climate change and land contamination. Both guidance documents advocate a "what if" scenario approach in the context of changes in ambient temperatures, an increase in the frequency of extreme rainfall/storm events and heatwaves/droughts, and long-term changes in groundwater and sea levels.

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

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

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

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

4. Ground investigations

4.1 Site works

The ground investigation works, including the rationale which was based on, and the findings of the preliminary risk assessment is summarised in Table 4-1. For the investigation rationale of the historical investigations, please refer to the historical reports as listed in Section 1.4.

The fieldwork took place between 14th and 17th March 2023, with post-fieldwork monitoring to date taking place on 22nd March, 4th April and 13th April. A further 3 rounds are proposed. The ground investigation locations were surveyed in using a topographic survey quality and are shown on the Exploratory Hole Location Plan (Hydrock Drawing 27471-HYD-XX-XX-DR-GE-0001) in **Appendix A**.

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

The weather conditions during the Hydrock fieldwork and for the previous week were overcast and rain.

Table 4-1: Summary of site works

Activity	Method	No.	Name	Maximum Depth (m bgl)	In situ tests	Rationale
Drilling, Pitting and Probing						
Boreholes	Cable percussive	1	BH2A	20	SPT	To investigate thickness of Gerrards Cross Gravels and strength profile of the London Clay Formation.
	Windowless sampler	4	WS01-04	6	SPT	For general site coverage, collection of samples and installation of groundwater / gas monitoring wells.
Trial pits	Machine (JCB 3X)	7	TP7 - 10, TP11 - TP13 & TPWS3	3	-	For general site coverage and collection of samples.
Probes	Dynamic probe	4	DP01 - 04	8	-	To investigate strength profile of soils on site.
	TRL dynamic cone penetrometer	7	TRL01 - 07		California Bearing Ratio (CBR)	To investigate strength profile of shallow soils for pavement design.

5 No. Well for monitoring groundwater levels and ground gas concentrations were installed in the cable percussive borehole and 4 No. windowless sampler boreholes. A summary of the monitoring well installations is presented in Table 4-2.

Table 4-2: Summary of monitoring installations

Location	Ground level (m OD)	Standpipe / piezometer diameter	Screen top and base depth (m bgl)	Screen top and base elevation (m OD)	Strata targeted
BH2A	86.04	50	0.80 - 1.80	85.24 - 84.24	Gerrards Cross Gravels
WS01	85.96	50	0.50 - 1.30	85.46 - 84.66	Made Ground
WS02	85.90	50	1.30 - 1.80	84.60 - 84.10	Gerrards Cross Gravels
WS03	86.43	50	0.70 - 1.20	85.73 - 85.23	Made Ground
WS04	86.24	50	0.50 - 1.20	85.74 - 85.04	Made Ground

4.2 Geo-environmental testing

4.2.1 Sampling strategy and protocols

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

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

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

4.2.2 Site screening tests

A photoionization detector (PID) (MINIRAE lite) was used during the fieldwork to screen samples. The PID readings are detailed on the exploratory hole logs in **Appendix D**.

4.2.3 Geo-environmental monitoring

Gas monitoring boreholes have been monitored on 3No. occasions. The results are presented in **Appendix F**. Monitoring is ongoing and this report will be updated on completion of the monitoring.

4.2.4 Geo-environmental laboratory analyses

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

The chemical test certificates for testing undertaken as part of historical investigations are provided in the relevant reports as listed in Section 1.4.

The geo-environmental analyses undertaken on soils are summarised in Table 4-3.

Table 4-3: Geo-environmental analyses of soils.

Determinand Suite	Made Ground	Topsoil	Gerrards Cross Gravels
Hydrock minimum suite of determinands for solids*	6	3	1
Speciated aliphatic and aromatic banding Total petroleum hydrocarbons by HS-GC/MS and GC/FID (Hydrock Tier 2 TPH Suite)	6	3	1
Volatile organic compounds (VOC target list) by HS-GC/MS	1	-	1
Semi-volatile organic compounds (SVOC target list) by GC-MS	1	-	1
Total Organic Carbon	3	3	-

*Hydrock minimum soil suite comprises: As, B (water soluble), Be, Cd, Cr (total), Cr (VI), Cu, Hg, Ni, Pb, S (elemental), Se, V, Zn, cyanide (total), sulfide, pH, asbestos fibres, speciated polynuclear aromatic hydrocarbons (PAH, by GC-FID), total phenols and fraction of organic carbon

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

The geo-environmental analyses undertaken as part of Hydrock's investigation on waters are summarised in Table 4-4.

Table 4-4: Geo-environmental analyses of waters.

Determinand Suite	Groundwater
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

The groundwater chemical test data are interpreted and assessed in Section 7.4.

4.2.5 *Geotechnical laboratory testing*

The geotechnical tests undertaken by Hydrock are summarised in Table 4-5 and the test certificates are provided in **Appendix E**. Wherever possible, UKAS accredited procedures have been used.

The geotechnical tests undertaken as part of historical investigations are provided in the relevant reports as listed in Section 1.4.

Table 4-5: Summary of sample numbers for geotechnical tests

Test	Made Ground	Gerrards Cross Gravels	Weathered London Clay Formation	London Clay Formation
Natural moisture content	1	-	2	5
Atterberg limits	1	-	2	5

Particle size distribution (wet sieve)	-	4	-	-
Single stage undrained triaxial compressive strength	-	-	1	2
One dimensional consolidation test	-	-	-	1
Sulfate and aggressive chemical environment classification for buried concrete classification (full BRE SD1 suite)	-	-	1	3

The geotechnical test data are summarised in Section 5.55 and interpreted in Section 1.

4.3 Constraints

Exploratory hole locations were limited on site to areas of accessible soft landscaping.

While on site, exploratory locations had to be moved to accommodate for the presence of services, and into locations accessible by plant.

5. Ground investigation records and data

5.1 Physical ground conditions

5.1.1 Summary of strata encountered

The following section 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.

Details of the Hydrock ground investigation works are provided in the logs 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.

Table 5-1: Strata encountered

Stratum	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m) (range)	Thickness (m) (average)
Topsoil	GL*	0.25 – 0.50	0.25 – 0.50	0.32
'General' Made Ground	GL* – 0.50	0.40 – 1.50	0.40 – 1.20	0.71
Gerrards Cross Gravels	0.70 – 1.50	1.80 – 2.50	0.60 – 1.50	1.03
Weathered London Clay Formation	1.00 – 2.50	4.50	2.00	2.00
London Clay Formation	1.80 – 4.50	Base not proven	Base not proven	Base not proven

*GL – Ground Level

5.1.2 Surface covering

The following surface cover was identified during the fieldworks:

- Concrete paved hardstanding covering approximately 10% of the site.
- Bituminous bound pavement hardstanding, covering approximately 40% of the site and noted to be in good condition to fair condition.
- Vegetation (grass, trees, brambles), covering approximately 50% of the site.

5.1.3 Made Ground

Made Ground was recorded across the entire site. it varied in composition across the site and generally it could be described as grey to brown gravelly and/or sandy CLAY. Gravel is fine to coarse, angular to subangular brick and flint. The Made Ground was noted to be between 0.40 and 1.20m thick, with an average thickness of 0.71m.

5.1.4 Gerrards Cross Gravels

The Gerrards Cross Gravels were encountered in 6 No locations across the site below Made Ground. It's composition was generally described as orange to brown slightly silty SAND and GRAVEL, Gravel is fine to coarse rounded to subangular flint and quartz. The Gerrards Cross Gravels are between 0.60m and 1.50m thick, with an average thickness of 1.03m.

5.1.5 *Weathered London Clay Formation*

Weathered London Clay Formation was encountered underlying the Gerrards Cross Gravels at 3 No. locations and is approximately 2.00m thick. It's composition was generally described as firm mottled orangish brown CLAY. The base was only proven in one exploratory location (BH2A).

5.1.6 *London Clay Formation*

London Clay Formation was encountered underlying the Gerrards Cross Gravels and weathered London Clay Formation and is >13.50m thick. The base was not proven at any exploratory location. It's composition was generally described as firm to stiff dark greyish brown CLAY.

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	TP07	1.40	Obstruction encountered. Pit flooding with water.
Made Ground	TP08	1.60	Concrete obstruction. Unable to progress.
Made Ground	TP09	0.50	Plastic water/drainage pipe uncovered (Not on service plans). Hole Terminated.
Made Ground	TP10	0.80	Plastic water/drainage pipe uncovered (Not on service plans). Hole Terminated.
Made Ground	TP12	0.40	Concrete obstruction. Unable to progress.
Made Ground	TP13	0.30	Concrete obstruction. Unable to progress.

5.3 Groundwater

5.3.1 *Groundwater observations and levels*

Confirmed groundwater was not encountered during the intrusive investigation.

Groundwater levels recorded during post-fieldwork monitoring are summarised in Table 5-3.

Table 5-3: Groundwater level data summary

Location	Date range (3 visits*)	Post-fieldwork monitoring	
		Depth to groundwater (range) (m bgl)	Groundwater elevation (range) (m OD)
BH2A	22/03/23 – 13/04/23	0.39 – 0.81	85.65 – 85.23
WS01	22/03/23 – 13/04/23	0.69 – 0.79	85.27 – 85.17
WS02	22/03/23 – 13/04/23	0.66 – 0.79	85.24 – 85.11
WS03	22/03/23 – 13/04/23	0.37 – 0.75	86.06 – 85.68
WS04	22/03/23 – 13/04/23	0.67 – 0.76	85.57 – 85.48

*6 visits are planned – this table will be updated in a future revision of this report.

5.3.2 Groundwater summary

During the site investigation groundwater was not encountered in any of the exploratory hole locations.

However, it was noted on site that a boiler house had burst a water pipe and had been leaking for an unknown amount of time prior to Hydrock's investigation. As such, during some of the trial pitting when service runs were encountered, water would flood into the excavation. This is thought to be as a result of the shingle filled service runs being inundated with water from the leak. This may also have had an effect on the fieldwork groundwater strike observations, and the post fieldwork monitoring results.

The ground conditions encountered were not suitable to carry out infiltration testing (due to shallow groundwater located between 0.37 & 0.81m bgl). BRE 365 requires at least 1m of natural unsaturated zone for testing and according to guidance, and there needs to be sufficient room to install a soakaway to meet the design requirements of BRE 365.

Based on the updated ground information from March 2023, the Gerrards Cross Gravels were 1.03m thick on average, and at some locations this stratum was absent (Made Ground on top of London Clay Formation at TPWS3). For these reasons, the site does not have ground conditions suitable for soakaway drainage.

5.4 Ground gases

Records from the gas monitoring boreholes are presented in **Appendix F** and summarised in Table 5-4.

To date three monitoring visits have been undertaken, with a further 3 visits to be undertaken as part of the current commission. The data are assessed in Section 7.5.

Table 5-4: Range of ground gas data

Stratum	Methane (% v/v)	Carbon dioxide (% v/v)	Oxygen (% v/v)	Carbon Monoxide (ppm)	Steady flow rate (l/hr)	Comment
Made Ground	<0.1	0.1 - 0.9	11.4 - 20.4	<1 -10	<0.1	All readings of CO_2 <5%. All methane readings <0.1%.
Gerrards Cross Gravels	<0.1	0.6 – 2.2	13.8 – 19.1	<1 – 53	<0.1	All readings of CO_2 <5%. All methane readings <0.1%. CO present in BH2A and WS03, however well screen at BH2A found to be flooded in two out of three monitoring rounds – suspected to be associated with the service leak.

5.5 Geotechnical data

5.5.1 *Introduction*

Laboratory test results are contained in **Appendix E** with *in situ* test results shown on the relevant exploratory hole log or datasheet in **Appendix D**. 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 5-5. The Aline plot is presented in Figure 5.1.

Table 5-5: Volume change potential

Stratum	No. of tests	Plasticity Index			Modified Plasticity Index			Plasticity designation	Volume Change Potential
		Min.	Max.	Av.	Min.	Max.	Av.		
Made Ground	1	27	27	27	24.5	25	25	Medium	Medium
Weathered London Clay Formation	2	39	50	45	39	50	44	High to Very High	Medium to High
London Clay formation	5	40	43	41.	30	43	39	High to Very High	Medium to High

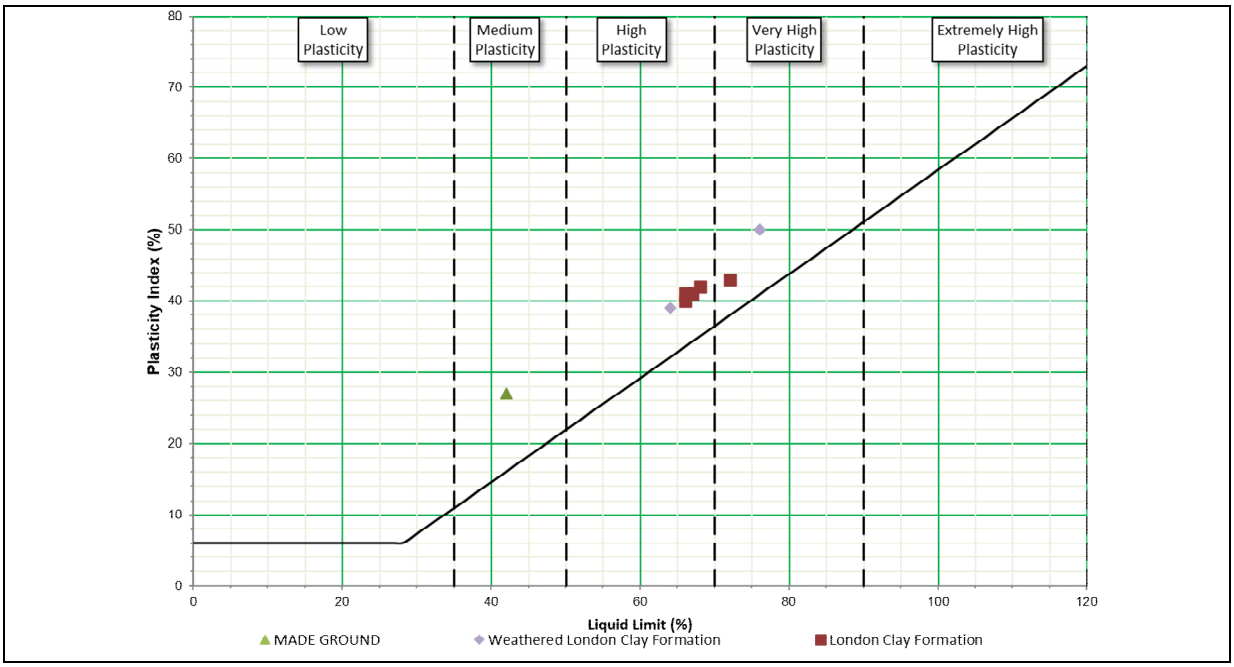


Figure 5.1: A-line plot

5.5.3 Particle size distribution

Particle Size Distribution test (PSDs) results are summarised in Table 5-6 and summary descriptions and PSD plots of the material analysed are presented in **Appendix E**.

Table 5-6: PSD results summary

Stratum	No. of tests	Silt/Clay %	Sand %	Gravel %	General description
Gerrards Cross Gravels	4	8 - 15	22 - 68	19 - 70	Yellowish brown sand and gravel

5.5.4 Soil strength

Table 5-7 summarises information pertaining to the shear strength of the soils according to geological stratum. Factual results are summarised for laboratory tests, field tests (e.g. hand shear vane) and uncorrected Standard Penetration Tests (SPT). Where the SPT or plasticity index data is used to infer shear strength by published correlation, this is also tabulated. An SPT N and undrained shear strength versus depth profile is presented in Figure 5.2 and Figure 5.3, respectively.

Table 5-7: Soil strength results and derived values

Stratum	No. of tests	SPT (N-value) (range)	c_u (kPa)[1]	c' (kPa) [4]	phi' (°)	Method
Made Ground	20	0 – 19	<20 – 80	-	22[2]	SPT & SHDP testing and correlations.
Gerrards Cross Gravels	22	4 – 97*	-	-	36[3]	SPT & SHDP testing and correlations.
Weathered London Clay Formation (approx. ≤4mBGL)	3	7 – 21	30 – 90	1.5 – 4.5	20[2]	SPT testing and correlations.
	~16	3 – 21	<20 - 95		-	SHDP testing
	1	-	86	4	-	Laboratory triaxial test
London Clay Formation (approx. >4mBGL)	14	10 - 27	44 - 118	2 - 5	21[2]	SPT testing and correlations.
	52	13 - 88*	45 - >250		-	SPT testing and correlations.
	2	-	134 - 142	6 – 7	-	Laboratory triaxial test

[1] Calculated using an f1 value of 4.4 based on average plasticity

[2] Calculated following guidance in Sorensen and Okkels, 2013

[3] Calculated based on BS 8002:2015

[4] Approximated based on 5% of undrained shear strength

*Highest values based on DP correlations

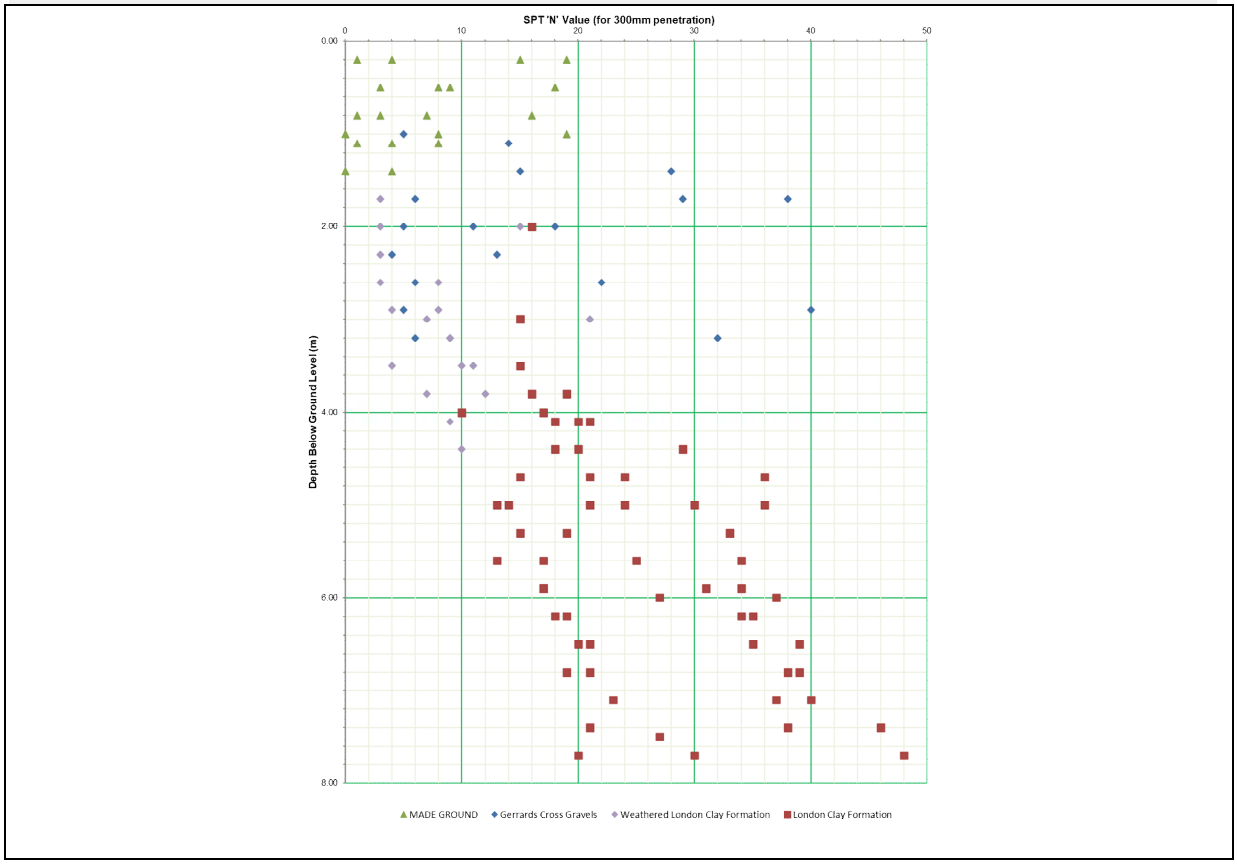


Figure 5.2: SPT N results from boreholes and dynamic probes

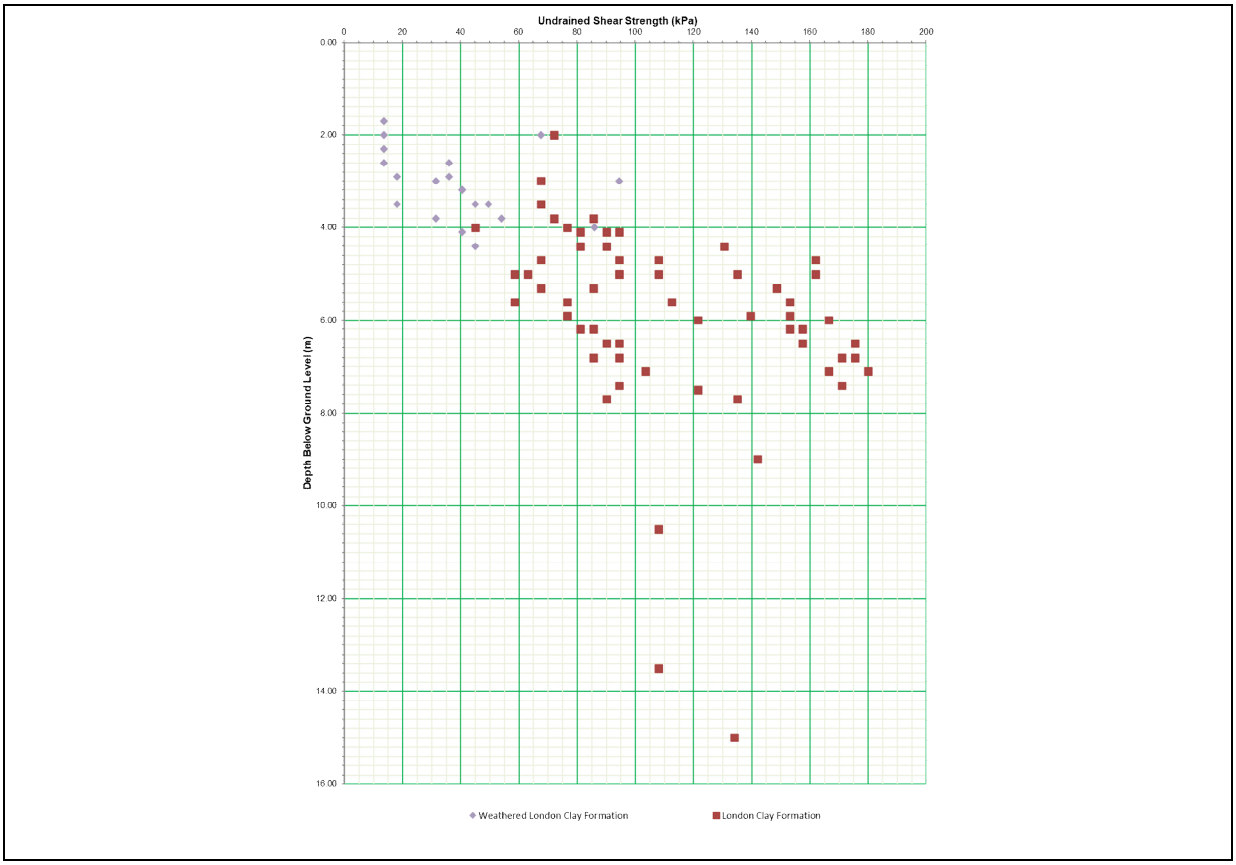


Figure 5.3: Undrained shear strength results as derived from in situ and laboratory testing

5.5.5 Relative density

Table 5-8 summarises information pertaining to the relative density of the granular soils according to geological stratum. Factual results are summarised for laboratory tests, field tests (e.g. SPT, CPT, dynamic probe correlation).

Table 5-8: Relative density results and derived values

Stratum	No. of tests	Method	SPT (N-value) (Range)	Relative density	Density Index, I_D
Gerrards Cross Gravels	4	SPT testing	4 – 56	Loose to medium dense, locally very dense	~20% to 50%, locally >80%
	22	SHDP testing	13 - 97	Medium dense to dense, locally very dense	~20% to 50%, locally >80%

5.5.6 Compressibility

Table 5-9 presents a summary of the measured values of coefficient of volume compressibility and consolidation. No geology factors are applied to the presented values of coefficient of volume compressibility.

Table 5-9: Summary of compressibility testing

Stratum	No. of tests / results	Method	Pressure range (kPa)	Coefficient of volume compressibility, m_v (m^2/MN)	Coefficient of consolidation, t_{50} log method, C_v (m^2/yr)
London Clay Formation	1	One Dimensional Oedometer Testing	150 – 300	0.20	0.7
			300 - 600	0.13	0.84
			600 - 1200	0.078	0.52
			1200 - 2400	0.047	0.5
			2400 - 1200	0.011	-

Table 5-10 presents the interpretation of Young's Modulus derived from laboratory and in situ testing. Geology factors are included in the presented values.

Table 5-10 Summary of compressibility interpretation

Stratum	No. of tests / results	Method	Pressure range (kPa)	Vertical, large-strain Young's Modulus, E' (MPa)
Made Ground	Variable strata, unsuitable for founding			
Gerrards Cross Gravels	SPT & SHDP	Correlation with SPT and SHDP	-	5 – 40 [1]
Weathered London Clay Formation (approx. ≤4mBGL)	SPT & SHDP	Correlation with SPT and SHDP*	-	3 – 19 [2]
London Clay Formation (approx. >4mBGL)	SPT & SHDP	Correlation with SPT and SHDP*	-	9 – 40 [2]
	1	One-dimensional Oedometer Testing	150 – 300	8 [3]
			300 – 600	12 [3]
			600 – 1200	19 [3]
			1200 – 2400	32 [3]
			2400 – 1200	135 [3]

[1] Based on Stroud, 1989, for normally consolidated sand

[2] Based on Stroud, 1989, for high plasticity clay

[3] Based on geology factor of 0.5 and conversion from confined modulus using Poisson's ratio of 0.3

5.5.7 *Subgrade stiffness*

The subgrade stiffness (CBR and Subgrade Surface Modulus) results are summarised in Table 5-11. The site records are included in **Appendix E**.

Table 5-11: CBR results and derived values

Stratum	No. tests	Method	Subgrade Surface Modulus (MPa) (Range)	CBR (%) (Range)
Made Ground	7	TRL DCP probe	35.5 - 180.5[2]	3 - 38% [1]

[1] Results from TRL probe locations DCP2, 4 and 6 have been excluded due to hitting obstructions

[2] Based on CBR results using equation 2-1 in CD225

5.5.8 *Sulfate content*

In accordance with BRE (Special Digest 1), the Design Sulfate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 5-12. The assessment summary sheets are presented in **Appendix E**.

Table 5-12: Aggressive chemical environment concrete classification

Stratum	No. tests	Design Sulfate Class	ACEC Class
Weathered London Clay Formation	1 [1]	DS-1 [1]	AC-1 [1]
London Clay Formation	3	DS-4	AC-4

[1] It is expected that pyrite is present within the strata and therefore the one test result suggesting DS-1, AC-1 shall only be adopted subject to confirmatory testing; otherwise adopt DS-4, AC-4.

6. Geotechnical assessment

6.1 Geotechnical categorization of the proposed development

BS EN 1997-1 (EC 7) advocates the use of geotechnical categorisation of the proposed structures to establish the design requirements.

The proposed development is to comprise low rise (2 to 3 storey) school building, with associated landscaping, and infrastructure. An initial review of the proposed finished levels indicates that minimal cut or fill is required and there is no requirement for steep slopes or retaining walls. Considering drainage, it is expected that the proposed surface water drainage will tie into the existing infrastructure.

Based on the above, for the purposes of this investigation, the proposed structures have been classed as Geotechnical Category 1.

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

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

6.2 Characteristic design values

For design of Category 1 structures, the geotechnical parameters given in Table 6-1 are deemed broadly applicable. For detailed design, the designer shall determine the appropriate ground model and geotechnical parameters based on the locality.

These values have been determined from laboratory testing, *in situ* testing and by professional judgement using published data together with knowledge and experience of the ground conditions.

The parameters presented are not proposed for use for any purpose beyond the scope of this report. The designer should refer to the original test results summarised in Section 5 and provided in **Appendix D** and **Appendix E**.

Table 6-1: Geotechnical parameters recommended for design of Geotechnical Category 1 Structures (EC7)

Parameter Stratum	Bulk unit weight kN/m³	Effective angle of internal friction °	Effective cohesion kPa	Undrained shear strength kPa	Vertical, large-strain Young's Modulus MPa	Subgrade Surface Modulus MPa
	γ [1]	ϕ'	c'	c_u	E'	E_r
Made Ground	Variable strata, unsuitable for founding					35 [2]
Gerrards Cross Gravels	18	36	0	-	10	75 [3]
Weathered London Clay Formation	19	20	1+0.5z, where z is m from 2mBGL,	15+15z, where z is m from 2mBGL, to	3+3z, where z is m from 2mBGL, to	~10 [4]

Parameter Stratum	Bulk unit weight kN/m³	Effective angle of internal friction °	Effective cohesion kPa	Undrained shear strength kPa	Vertical, large-strain Young's Modulus MPa	Subgrade Surface Modulus MPa
	γ [1]	ϕ'	c'	c_u	E'	E_r
			to max. value of 2	max. value of 45	max. value of 9	
London Clay Formation	20	21	3+0.5z, where z is m from 4mBGL, to max. value of 5	60+15z, where z is m from 4mBGL, to max. value of 110	12+3z, where z is m from 4mBGL, to max. value of 22	35 [3]

[1] Measured as part of the triaxial strength testing and estimated based on the recommendations of BS 8002-2015

[2] Based on the minimum value from TRL-DCP probing. However, Made Ground is variable and a lower value should be expected during the works. Formation to be tested to verify conditions during construction.

[3] Approximation based on consideration of DMRB IAN 73/06 Rev 1 Table 5.1

[4] Based on very low SPT N blow count observed during SHDP testing

6.3 Groundwork

6.3.1 Site preparation

The redevelopment will involve extension of the existing building. It is not expected that material generated from the works will be reused. However, should this be proposed, material reuse must be carried out in accordance with a Remediation Strategy and Verification Plan and an Earthworks Specification prepared specifically for the works.

Buried obstructions were encountered during this investigation, which are believed to be associated with services, and there is a possibility of further such obstructions being encountered.

6.3.2 Groundworks

Following breaking out of hardstanding and obstructions, excavation of shallow soils should be readily undertaken by conventional plant and equipment.

Trial pit faces were noted to remain generally vertical without collapse. The faces of shallow, near vertically sided excavations put down at the site are likely to remain stable for short periods of time. However, excavation into the Gerrards Cross Gravels are likely to be unstable and sudden falls should be expected from the faces of near vertically sided excavations put down at the site.

Temporary trench support, or battering of excavation sides, is recommended for all excavations that are to be left open for any length of time and will definitely be required where man entry is required. Particular attention should be paid to excavation at, or close to, buildings, services, roads of other infrastructure, where collapse of excavation faces could have a disproportionate effect.

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practice 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).

Groundwater control by sump pumping is likely to be sufficient for water within the Made Ground. However, if excavations are to extend through the Gerrard Cross Gravels, additional measures may be required. The Contractor shall be responsible for control of water.

It should be recognised that although groundwater levels have been found close to ground level (~0.6mBGL), levels may vary in response to seasonal fluctuations and construction activities. The timing of construction may dictate the extent of groundwater control required.

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

6.3.3 Earthworks/reuse of site-won materials

At this stage, Hydrock is not aware of proposals for earthworks at the site. Once site proposals have been further defined more specific consideration will need to be given to the reuse of materials and reference should be made back to this office.

Should earthworks be required, supplementary earthworks testing and an Earthworks Specification shall be necessary to ensure the appropriate management and reuse of the existing soils.

6.4 Foundation recommendations

In accordance with EC7, the works are considered to be Geotechnical Category 1. Nevertheless, a Geotechnical Design Report is required to capture the detailed design of the foundations.

6.4.1 Foundation Type

The Made Ground is considered unsuitable in its present condition for use as founding soils 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 a new subgrade.

The Gerrards Cross Gravels are considered a competent founding stratum, however the extent of the gravels cannot be guaranteed, as proven by the ground investigation. This is potentially due to the material being removed during historic development of the site. It is also the case that foundation will be embedded in medium to very high volume change soils and trees are present. Therefore, strip foundations would need to extend beyond the base of the Gerrard Cross Gravels to comply with NHBC guidance. A foundation solution supported by the London Clay Formation is therefore required.

Considering the shallow ground conditions encountered in WS03, DP01 and DP03, the shrink-swell potential of the near-surface soils and strength of the anticipated founding strata, a pier and beam foundation solution is considered the most viable option. As per NHBC guidance, voids and heave precautions will be required.

6.4.2 Piled foundations

Piled foundations are recommended for the proposed extension of the school building.

Piles should extend through the Made Ground and Gerrards Cross Gravels to a suitable depth into the underlying London Clay Formation.

Continuous Flight Auger (CFA) piles are expected to be the most appropriate piling methodology. However, the choice of piling system should be confirmed by a specialist piling Contractor and the design of piles is beyond the scope of this report. The decision on pile type and design should take into account the following factors relevant to the site:

- Obstructions in the ground from the previous structures and services. Probing of proposed pile locations is advisable to prove the absence of obstructions.
- Works are to be carried out immediately adjacent to existing structures. Therefore, low noise and vibration options are expected to be preferable. Driven piling options cause high vibrations which can cause damage to adjacent structures.
- Boring of piles through coarse soils can result in loosening of the material, with resultant risk of shaft collapse prior to concreting and reduced shaft friction.
- Groundwater levels are shallow. Temporary casing may be required to depths of approximately 4m bgl through shallow soils into the London Clay Formation for bored piles. If CFA piles are used, concrete is placed as the auger is withdrawn, which can balance the water pressure if the operation is undertaken carefully.
- Piles in London Clay Formation should be sufficiently long to support the working load on the shaft alone. Reliance on the mobilisation of resistance at the base of the pile may result in unacceptable movements.
- Piles shall be within the influencing distance of trees and design should include for the upper section of the pile to be sleeved or additional length allowed for to resist stresses from clay swelling or shrinkage. Heave protection is required on the inside faces and underside of the ground beams and void is required below the floor slab.

6.4.3 Working platform

For piling, a working platform will be required prior to the arrival on site of tracked plant. This needs be designed and installed in accordance with BR470 (BRE 2004) based on specific FPS data for the proposed piling plant arrangement.

6.5 Roads and pavements

Based on the TRL probe test results a competent subgrade would be expected at ~0.7mBGL. However, results from DP01 and DP03 do not support this conclusion, as the Made Ground is variable and very low strength materials were encountered near-surface. Deep soft spots must be allowed for the pavement design.

Proof rolling of the formation level will be required and any loose or soft spots should be removed and replaced with an engineered fill, in accordance with a suitable Specification. The formation level will also need to be protected 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 in accordance with a suitable specification to ensure the ground conditions are as expected. All testing should be carried out in accordance with DMRB CD 225 Rev 1 (2020) to confirm that the ground conditions at time of construction are consistent with those adopted in design.

Where the Subgrade Surface Modulus is found to be less than 35MPa, the subgrade 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 CD 225 Rev 1 (2020) . 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 subgrade

6.6 Drainage

It is understood that the existing drainage system on site will be utilised. Hydrock has not considered drainage any further.

6.7 Buried concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005) and the information presented in Section 5.5.8 (Table 5-12):

» The deeper soils that will be founded in (London Clay Formation) shall be classified as Design Sulfate Class DS-4 and ACEC Class AC-4

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. On that basis, Design Chemical Classes are as follows:

» DC-4 for the London Clay Formation, where materials are exposed

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

7. Geo-environmental assessment

7.1 Updated conceptual model

7.1.1 Updated ground model

The initial CSM developed from the desk study and field reconnaissance survey Section 3 has been updated using the findings of the ground investigation and is presented in Section 5. This CSM 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 3 have been updated or confirmed as follows.

7.1.2.1 Sources

The following potential sources have been removed from the exposure model.

- Made Ground, potentially containing asbestos fibres and Asbestos Containing Materials from demolition of former school buildings as laboratory test data did not detect ACM in any of the samples.

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

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

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

The data sets used in the assessment comprise the analytical results obtained by Hydrock as listed in Section 5.

7.3 Human health risk assessment

7.3.1 Soils Assessment

7.3.1.1 Generic Assessment Criteria

The soil screening values used are generic assessment criteria (GAC) (i.e. derived in accordance with EA CLEA guidance (2009) using the updated exposure model detailed in Defra SP1010 (2014),

with the exception of published C4SLs. The term 'GAC' used in this report is inclusive of all generic soil screening values.

Based on the proposed development, generic assessment criteria (GAC) based on a default residential without homegrown produce CLEA land use scenario has been adopted, as a conservative scenario for the proposed school development.

GAC are selected based on the following hierarchy:

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

The results of the assessment are presented in **Appendix G**.

7.3.1.2 Data sets

The data set used in this report is based on the conceptual site model and the proposed development, and is taken to be the entire area of the site.

GAC based on a soil organic matter (SOM) of 1% have been adopted for all soils based on laboratory results. Assessment sheets are presented in **Appendix G**. This is due to the range of SOM concentrations identified during the ground investigation, and 1% being the more conservative scenario.

7.3.1.3 Assessment Results

Based on individual test results that exceed the GAC, the chemicals of potential concern (CoPC) which require further assessment are summarised in Table 7-1.

Table 7-1: CoPC in soils which require further assessment (human health)

CoPC	GAC (mg/kg)	GAC Source	No. samples	Min. (mg/kg)	Max. (mg/kg)	No. samples >GAC	Location
Dibenz(ah)anthracene	0.32	Hydrock Derived GAC	10	0.05	0.42	1	WS4 at 0.1m bgl (topsoil)

This exceedance requires further consideration.

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

7.3.1.4 Asbestos

No evidence of Asbestos Containing Materials (ACM) was identified during the ground investigation.

10 samples were submitted to the laboratory for asbestos screening analysis and asbestos was not positively identified in any of the samples. Groundwater (dissolved phase) assessment

The risks to human health arising from vapours in dissolved phase groundwater have been assessed in accordance with the SoBRA GW GAC guidance (2017). This is a preliminary approach whereby GAC have been developed using the CLEA v1.071 model for indoor air and outdoor inhalation pathways only, assuming a residential or commercial end-use.

A review of the groundwater screening values, indicate a low risk with regard to dissolved phase VOC in groundwater. As such, dissolved phase VOC in groundwater does not require further consideration.

7.3.2 Risk evaluation

The screening exercise has identified Dibenz(ah)anthracene in topsoil at concentrations above the GAC. This is considered further here to assess if the exceedance may be acceptable with respect to the proposed development. The phrase 'further assessment' does not necessarily mean that the soil is 'contaminated' or not fit for use.

7.3.2.1 Dibenz(ah)anthracene in topsoil

Dibenz(ah)anthracene is present in the topsoil at an upper confidence limit (UCL) of 0.21 mg/kg, which is less than the GAC of 0.32 mg/kg and the exceedance of the GAC in lab testing is likely caused by an outlier result. The assessment criteria of residential without homegrown produce used is also highly conservative, as there are no published assessment criteria specifically for land use as a school. Given the actual proposed land use of a secondary school, the exposure time and frequency for human receptors will be reduced compared to a residential land use, and therefore this exceedance is not considered to be an unacceptable risk to human health and no further consideration is required.

7.4 Pollution of controlled waters risk assessment

7.4.1 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 (WQTs), which are linked to the CSM.

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 G**. This methodology involves selecting which of several alternative risk scenarios apply in this case. The assessment is presented in Table 7-2 below, with the justification for the scenarios selected explained in the following text:

- The site lies within a Source Protection Zone 2 (SPZ2).
- There is potential for contaminants from the Made Ground to leach into the secondary aquifer of the Gerrards Cross Gravels as they are not separated by an aquiclude.
- There is an active potable water extraction located 852m west of the site (although this is likely to be abstraction from the deeper Chalk, rather than the Gerrards Cross Gravels, but this is not confirmed by the records available).

As the site is underlain by London Clay Formation (>15m thickness proven on site), which would act as an aquiclude, and there are no known abstractions from within the Gerrards Cross Gravels, the DWS scenario for controlled waters is not considered any further in this report.

The Made Ground is expected to be in continuity with the Gerrards Cross Gravels, which is expected to provide base flow to nearby surface water, therefore the data has been assessed against EQS only.

Table 7-2: 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
B	Groundwater and Surface Water	Ecology	Contaminants from site leach or seep into a groundwater body that is in continuity with surface water.	RTM Level 1.	EQS

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 G** and are summarised in Table 7-3.

There are no WQT for petroleum hydrocarbons in water. Consequently, Hydrock has calculated risk-based guidelines for drinking water based on a methodology proposed by the WHO and using the tolerable daily intakes for the various TPH fractions as used in the derivation of the soil GAC. The results are included in Table 7-3.

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 7-3: CoPC which require further assessment (controlled waters)

CoPC	WQT (µg/l)	Basis for WQT	No. samples	No. samples above LoD	Min. (µg/l)	Max. (µg/l)	No. samples exceeding WQT and above LoD
Shallow groundwater in the Made Ground / Gerrard Cross Gravels							
Cadmium	0.08	EQS	3	3	<0.02	0.18	1
Cobalt	3	EQS	3	3	1.9	21	1
Copper	1	EQS	3	3	6.5	34	3
Manganese	123	EQS	3	3	45	680	1
Nickel	4	EQS	3	3	8.7	33	3
Ammoniacal Nitrogen as N	300	EQS	3	3	73	560	2

CoPC	WQT (µg/l)	Basis for WQT	No. samples	No. samples above LoD	Min. (µg/l)	Max. (µg/l)	No. samples exceeding WQT and above LoD
Sulphate (as SO_4)	40000	EQS	3	3	304000	497000	1

Note: the maximum recorded value is compared with the water quality target.

7.4.2 Risk evaluation

The EQS for cadmium, cobalt, copper, cobalt, manganese, nickel, ammoniacal nitrogen and sulphate are exceeded. Concentrations of petroleum hydrocarbons were not recorded above the limit of detection.

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

Chemical testing has not indicated significantly elevated concentrations of these metals in the soils at the site.

Whilst some exceedances have been recorded in the metals listed in Table 7-3, it is considered unlikely that the risks are significant based on the conservative approach in regard to bioavailability. Furthermore, the levels of contamination are unlikely to be improved by practicable treatment methods indicating such efforts would not be suitable.

The investigation in the area noted very little in the way of definite sources which may have contributed to these exceedances, and it is considered probable that the levels recorded are in line with background levels in the area.

On this basis Hydrock believes that there is not an unacceptable risk to Controlled Waters, and that the risks do not need further consideration.

7.5 Ground gases risk assessment

For the ground gas assessment, reference was made to CL:AIRE Research Bulletin 17[4] (Card et al 2012) states that where there are natural soils with low organic content and 1m to 5m of Made Ground (average <3m) that comprises general infill and car park construction materials and a TOC less than 1%, no gas protection is required as this represents CS1.

The range of concentrations identified for TOC within the topsoil and Made Ground was 1.2 to 3.5%.

Topsoil will be stripped as part of the construction process – this will remove three of the higher TOC results of between 2.2% (WS4 at 0.10m bgl) and 3.5% (WS1 at 0.1mbgl). The maximum TOC concentration for the MG is 2.4%, with the average being 1.9%. Based on this, according to CL:AIRE Research Bulletin 17 the site would fall under CS2 conditions (as TOC concentrations are <3% in Made Ground which has been in place for more than 20 years).

However, in addition to this, the maximum Made Ground thickness identified within the 2023 investigation is 1.2m, with an average thickness of 0.71m, and it is considered that this will largely be removed as part of the construction works for the proposed development. This will remove the source of any ground gas.

[4] CL:AIRE 2012. A Pragmatic Approach to Ground Gas Risk Assessment, Research Bulletin 17.

Monitoring data also supports that any MG that may remain will not be a risk, as 3 rounds (of 6) have indicated zero flow from all monitoring locations.

Therefore, although it appears that ground gas protection measures were used for the existing building, based on the recent data, ground gas protection measures are not considered necessary for the extension. This will be confirmed following the final three post-fieldwork monitoring visits. As such, no ground gas protection is currently proposed, however this will be confirmed in an updated version of this report following completion of the post-fieldwork monitoring.

7.6 Construction materials risk assessment

7.6.1 Water pipelines

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

The site is previously developed and the preliminary risk assessment and investigation has indicated no plausible contaminant sources. It is envisaged that standard pipework will be suitable for the site. However, confirmation should be sought from the water supply company at the earliest opportunity.

7.6.2 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 are discussed in Section 6.7.

7.7 Findings of the generic contamination risk assessments

The potential sources, pathways and receptors identified in the desk study (Section 2) have been investigated (Sections 4 and 5) and assessed (Section 7.3 to 7.6). A Source-Pathway-Receptor linkage assessment has been undertaken and is presented in **Appendix J** (Table J.2).

A summary of the Source-Pathway-Receptor (SPR) contaminant linkages for which the risks may be unacceptable and require mitigation (those that are moderate or higher) are discussed in Table 7-4.

Table 7-4 assumes the following SPR linkages which have been discounted (subject to agreement) at the risk evaluation stage are confirmed by the regulators and the warranty provider as not requiring further consideration (mitigation). If these assumptions are not agreed during regulatory discussions, the conclusions as noted in Table 7-4 will need to be updated:

- Removal of pile arisings.
- Generation of dust during the construction phase of the development.
- Asbestos discovery strategy. Although no asbestos was found during Hydrock's investigation there is always potential for Made Ground soils to contains ACM. As such a discovery strategy for the proposed development should be in place in case Made Ground is encountered during the construction works.
- Elevated concentrations of Manganese, Nickel, Selenium, Ammoniacal Nitrogen, Nitrite, and Sulfate within groundwater. However, the exceedances are slight, and it is considered that

specific remedial measures would be technically challenging, disproportionate and would yield no measurable improvement in groundwater quality.

Table 7-4: Residual risks following risk evaluation

Contaminant Linkage				Comments	
Pollutant Linkage	Sources	Pathways	Receptors	General	Mitigation
PL 1.	Made Ground.	Ingestion, inhalation or direct contact.	Human health.	Exceedance of GAC	Dust suppression methods when carrying out tasks that generate a significant quantity of dust.
PL 2.	(Made Ground) Asbestos	Ingestion, inhalation or direct contact.	Human health.	Possible in made ground soils	Works should be carried out using a discovery strategy. If asbestos is visually identified during the enablement phase mitigation steps should be taken to ensure safety of site staff in line with CAR 2012.

7.8 Mitigation measures

As shown in Table 7-4 (and subject to regulatory agreement, Hydrock consider the following mitigation is required to ensure the site is suitable for use for the proposed end use. The mitigation measures include:

- Dust suppression in case of works generating a significant quantity of dust. (PL1)
- An asbestos management plan to be in place in the event of discovery of asbestos in the Made Ground soils to ensure safety of site staff and to ensure works are carried out in accordance with CAR 2012. (PL2)

It is understood that ground gas protection measures are present within the existing building, therefore consideration will need to be given to tying in the foundations of the extension with the existing building.

7.8.1 Enablement phase

The following works are considered necessary during the Enablement Phase of works:

- break out of hardstanding and below ground obstructions not to remain for the development and processing for reuse in accordance with a suitable specification and a Materials Management Plan (MMP) if required;
- excavation of Made Ground and natural soils as required to allow construction with appropriate materials management and processing of excavated soils using a combination of: excavation and stockpiling and screening of soils to leave the site at the level required for the installation of a working platform and pavement construction.

- off-site disposal of unsuitable or excess material; and
- verification during enablement works.

Due to the potential for low concentrations of dissolved phase petroleum hydrocarbons in the groundwater, treatment of any water pumped from excavations (via a granulated activated carbon plant) may be required prior to discharge from the site. This would apply to both the enablement and construction phase of works.

7.8.2 Construction phase

The Construction Phase of works will comprise:

- appropriate materials handling and stockpiling in accordance with the Materials Management Plan (MMP);
- removal of pile arisings from site (if applicable); and
- import of subsoil and topsoil in accordance with the Materials Management Plan (MMP).

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 and Peat

Topsoil and peat are biodegradable, therefore if they are surplus to requirements and cannot be re-used in accordance with a Materials Management Plan, they cannot be classified as inert. As such, topsoil and peat need to be classified by a staged assessment and sampling process and would either be classified as hazardous or non-hazardous, depending upon the results of the assessment.

Greenfield sites

Waste from completely greenfield sites may be accepted at a landfill as inert waste if it meets the requirements of paragraph 10 (wastes acceptable without testing at landfills for inert waste) of the Landfill (England and Wales) (Amendment) Regulations (2005) ('the Regulations') can be met. Paragraph 10 of the Regulations states, "*soils may be able to be classified as inert waste without testing, if:*

- *they are single stream waste of a single waste type;*
- *there is no suspicion of contamination and they do not contain other material or substances such as metals, asbestos, plastics, chemicals, etc…..*"

As such, where the site is greenfield and the waste producer is confident about the quality of a soil (i.e. naturally occurring and uncontaminated), further sampling and laboratory testing is not necessary for the Basic Characterisation and this can be undertaken on qualitative Waste Acceptance Criteria testing.

In this instance the waste producer can characterise the waste based on visual assessment and written description of the waste in addition to supporting evidence such as a desk study assessment of the greenfield status. However, it should be noted this characterisation is subject to agreement by the landfill operator who may require testing to be undertaken to confirm classification.

Contaminated or potentially contaminated sites

If the site is brownfield, contaminated or potentially contaminated, the 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 H** and a summary of the preliminary waste classification is provided below in Section 8.2.4.

It should be noted that some of the soil samples assessed as part of the HazWasteOnline™ are classified as potentially hazardous on account of the designation 'HP3i' (with regards to petroleum hydrocarbons). However, based upon carbon banding of the TPH, the findings of the investigation and the way the petroleum hydrocarbons are distributed within the soil, it is likely that the potential for the soil being hazardous on account of HP3i can be all but discounted and it would be reasonable to assume that the result would indicate that the soil, would be non-hazardous as a result of the TPH content.

8.2.3 WAC testing

The site is brownfield. However, WAC testing has not been undertaken to date but will be required on the excavated soils that are to be disposed of, to assist with waste disposal options prior to disposal. A summary of the preliminary waste disposal options is provided below in Section 8.2.4.

8.2.4 Preliminary waste disposal options

The site is brownfield and based on the site history, laboratory 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 they are likely to be classified as non-hazardous waste.

If during the works any soils containing > 0.1% asbestos or visible asbestos containing materials are discovered, these 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 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[5]:
  - 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 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

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

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 Clean, naturally occurring materials – transferred to other sites

Where soils are naturally occurring, uncontaminated and are transferred to other sites (i.e. direct transfer), they will not become waste as long as the transfer is undertaken in accordance with the DoWCoP. A MMP must be prepared for the receiving site and the materials movement must be noted in the MMP of the Donor site. This movement must have been declared to CL:AIRE prior to the works commencing.

8.3.2.3 Made Ground and 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.

8.3.2.4 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.

8.3.2.5 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 gas monitoring undertaken to date and included in this report is insufficient to fully characterise the site in accordance with CIRIA Report C665. Monitoring is ongoing and the conclusions of this report will be updated following completion of the scheduled monitoring.

9.2 General comments

Hydrock Consultants Limited (Hydrock) has prepared this report in accordance with the instructions of ISG Construction Ltd (the Client), 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 March-April 2023. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, not all potential environmental constraints or liabilities associated with the site may have been revealed.

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

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

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

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

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

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

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

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment

Agency Technical Guidance WM3, they are not primarily intended for that purpose and additional analysis will be required at the time of disposal to fully classify waste. Discussion and comment with regards to waste classification are preliminary and do not form the requirements of 'Basic Characterisation' as required.

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

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

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

The non-specialist UXO screening has been undertaken for the purposes of ground investigation only (i.e. low risk activity in accordance with CIRIA Report C681). Further assessment should be undertaken with regards to other higher risk activities e.g. construction.

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

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

10. Recommendations for further work

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

- completion and reporting of the ongoing gas monitoring, hence the conclusions in this report are provisional, subject to the completion of monitoring;
- discussion and agreement with utility providers regarding the materials suitable for pipework;
- discussions with regulatory bodies and the warranty provider regarding the conclusions of this report;
- assessment of tree influence on foundations and design of foundations;
- discussions with piling Contractors regarding conclusions of this report and design of the piles;
- provision of geotechnical design for the structure (piled foundations);
- production of a Materials Management Plan relating to reuse of soils at the site and import of soils to the site (if required);
- writing of a Materials Management Strategy relating to reuse of soils at the site (if required);
- writing of a Discovery Strategy, as a full Remediation Strategy and Verification Report is not required based on the findings of this report;
- mitigation works; and
- verification of the mitigation works.

11. References

ASSOCIATION OF GROUND INVESTIGATION SPECIALISTS. 2006. Guidelines for Good Practice in Site Investigation. Issue 2. AGS, Beckenham.

ASSOCIATION OF GROUND INVESTIGATION SPECIALISTS. 2019. Waste Classification for Soils – A Practitioners' Guide. AGS, Beckenham.

BRE. 1980. Low-rise buildings on shrinkable clay soils: Part 1. BRE Digest 240. Building Research Establishment, Garston.

BRE. 1999. The influence of trees on house foundations in clay soils. BRE Digest 298. Building Research Establishment, Garston.

BRE. 2016. Soakaway design. BRE DG 365. BRE, Garston.

BRE. 2004. Working platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground-supported working platforms. BR470. BRE, Garston.

BRE. 2005. Concrete in aggressive ground. BRE Special Digest 1, 3rd Edition. BRE, Garston.

BRITISH PLASTIC FEDERATION. August 2018. 'Designing Drains and Sewers for Brownfield Sites. Guidance Notes'. BPF Pipes Group (https://www.bpfpipesgroup.com/media/29155/Designing-drains-and-sewers-for-brownfield-sites.pdf)

BRITISH STANDARDS INSTITUTION. 2015. Code of Practice for Foundations. BS 8004. BSI, London.

BRITISH STANDARDS INSTITUTION. 2015+A2 2019. Concrete – complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance to the specifier. BS 8500-1+A2 2019. BSI, London.

BRITISH STANDARDS INSTITUTION. 2007. Eurocode 7 – Geotechnical design - Part 2: Geotechnical investigation and testing. BS EN 1997-2. BSI, London.

BRITISH STANDARDS INSTITUTION. 2009. Code of practice for earthworks. BS 6031 Incorporating Corrigendum No.1:2010. BSI, London.

BRITISH STANDARDS INSTITUTION. 2011. Code of Practice for Investigation of Potentially Contaminated sites. BS 10175 Incorporating Amendment No. 2:2017. BSI, London.

BRITISH STANDARDS INSTITUTION. 2012. Trees in relation to design, demolition and construction – Recommendations. BS 5837. BSI, London.

BRITISH STANDARDS INSTITUTION. 2004+A1 2013. Eurocode 7 – Geotechnical design - Part 1: General rules. BS EN 1997-1+A1. Incorporating Corrigendum February 2009. BSI, London.

BRITISH STANDARDS INSTITUTION. 2015. Specification for topsoil. BS 3882. BSI, London.

BRITISH STANDARDS INSTITUTION. 2015. Code of practice for ground investigations. BS 5930. BSI, London.

BRITISH STANDARDS INSTITUTION. 2015+A1 2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. BS 8485:2015 +A1:2019. BSI, London.

CARD, G., WILSON, S. and MORTIMER, S. 2012. A pragmatic approach to ground gas risk assessment. CL:AIRE Research Bulletin RB17. CL:AIRE, London.

CARD, G., LUCAS, J., WILSON, S., 2019. Risk and reliability in gas protection design - 20 years on. Ground Engineering, August/September 2019.

CL:AIRE, 2017. A Pragmatic Approach to Ground Gas Risk Assessment. Research Bulletin 17, CL:AIRE, Buckinghamshire. ISSN 2047-6450.

CL:AIRE, 2020. Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration. CL:AIRE, Buckinghamshire. ISBN 978-1-905046-35-5.

CL:AIRE, 2018. Ground gas monitoring and 'worst-case' conditions. Technical Bulletin 17, CL:AIRE, Buckinghamshire, August 2018.

CL:AIRE. March 2011. The Definition of Waste: Development Industry Code of Practice, Version 2. Contaminated Land: Applications in the Real Environment (CL:AIRE), London.

CL:AIRE. March 2016. CAR-SOIL™ Control of Asbestos Regulations 2012 - Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance. Contaminated Land: Applications in the Real Environment (CL:AIRE), London.

CLAYTON, C. R. I. 2001. Managing Geotechnical Risk. Improving productivity in UK building and construction. Thomas Telford, London.

CONCRETE SOCIETY, THE. 2013. Concrete industrial ground floors. A guide to design and construction. Technical Report 34 (4th Ed.). The Concrete Society, Camberley.

DEPARTMENT FOR ENVIRONMENT FOOD AND RURAL AFFAIRS (DEFRA). 2005. 'Landfill (England and Wales) (Amendment) Regulations', (with reference to previous iterations of the regulations).

DEFRA. March 2014. SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document. Defra, London.

ENVIRONMENT AGENCY. June 2001. National Groundwater and Contaminated Land Centre Report NC/99/73: Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention. The Environment Agency, Bristol.

ENVIRONMENT AGENCY. 2006. Remedial Targets Methodology. Hydrogeological Risk Assessment for Land Contamination. The Environment Agency, Bristol.

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

ENVIRONMENT AGENCY. November 2011. Treatment of waste for landfill. Report – GEHO1111BVDF-E-E 913_11, Version 2 The Environment Agency. http://publications.environment-agency.gov.uk/pdf/GEHO1111BVDF-E-E.pdf

ENVIRONMENT AGENCY. 2021. Waste classification. Guidance on the classification and assessment of waste (1st Edition v1.2.GB) Technical Guidance WM3. The Environment Agency.

ENVIRONMENT AGENCY. 2021. Land Contamination: Risk Management (LCRM). The Environment Agency.

HATANAKA, M, UCHIDA, A, KAKURAI, M, and AOKI, M. 1980. A consideration on the relationship between SPT N-value and internal friction angle of sandy soils. Journal of Structural and Construction Engineering (Transactions of AIJ). 63. 125-129. 10.3130/aijs.63.125_2.

HEALTH and SAFETY EXECUTIVE. December 2005. Construction Information Sheet 47: Inspections and Reports (CIS 47 (Rev 1)). HSE.

HEALTH and SAFETY EXECUTIVE. 2014. HSG47 - Avoiding danger from underground services (Third edition). HSE.

HIGHWAYS AGENCY. 2009. Design Guidance for Road Pavement Foundations (Draft HD25). Interim Advice Note 73/06. Rev 1. Highway Agency, London.

HIGHWAYS AGENCY. 2014. Manual of Contract Documents for Highway Works, Specification for Highway Works: Volume 1, Amendment August 2014. Highway Agency, London.

HIGHWAYS AGENCY. 2015. Design Manual, Road and Bridges: Volume 4, Geotechnics and Drainage; Section 1, Earthworks; Part 3, HD 41/15, Maintenance of highway geotechnical assets. HD 41/15.

HIGHWAYS AGENCY. 2019. Design Manual for Roads and Bridges. Managing Geotechnical Risk. CD 622 Rev 0. Highway Agency, London.

JONES, H. K., MORRIS, B. L., CHENEY, C. S., BREWERTON, L. J., MERRIN, P. D., LEWIS, M. A., MACDONALD, A. M., COLEBY, L. M., TALBOT, J. C., MCKENZIE, A. A., BIRD, M. J., CUNNINGHAM, J. and ROBINSON, V. K. 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report WD/00/04. 234pp. Environment Agency R and D Publication 68.

MILES, J. C. H., APPLETON, J. D., REES, D. M., GREEN, B. M. R., ADLAM. K. A. M. and MYRES. A. H. 2007. Indicative Atlas of Radon in England and Wales. Health Protection Agency and British Geological Survey. Report HPA-RPD-033.

MINISTRY OF HOUSING, COMMUNITIES and LOCAL GOVERNMENT (MHCLG). Internet published Planning practice guidance https://www.gov.uk/government/collections/planning-practice-guidance. MHCLG. London

NATHANAIL P., JONES A., OGDEN, R., AND ROBERTSON A. 2014. Asbestos in soil and made ground: a guide to understanding and managing risks. CIRIA Report C733 Contaminated Land: Applications in Real Environments, London.

NHBC. 2022. NHBC Standards. NHBC, Milton Keynes. https://nhbc-standards.co.uk/

PECK, R.B., HANSON, W.E., AND THORNBURN, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967, p.310.

RAWLINS, B. G., McGRATH, S. P., SCHEIB, A. J., CAVE, N., LISTER, T. R., INGHAM, M., GOWING, C. and CARTER, S. 2012 .The advanced geochemical atlas of England and Wales. British Geological Survey, Keyworth.

SCIVYER, C. 2015. Radon: Guidance on protective measures for new buildings. Building Research Establishment Report BR 211. BRE, Garston.

SHAND, P., EDMUNDS, W.M., LAWRENCE, A.R., SMEDLEY, PAULINE, BURKE, S. 2007. The natural (baseline) quality of groundwater in England and Wales. Environment Agency, 72pp. (RR/07/006)

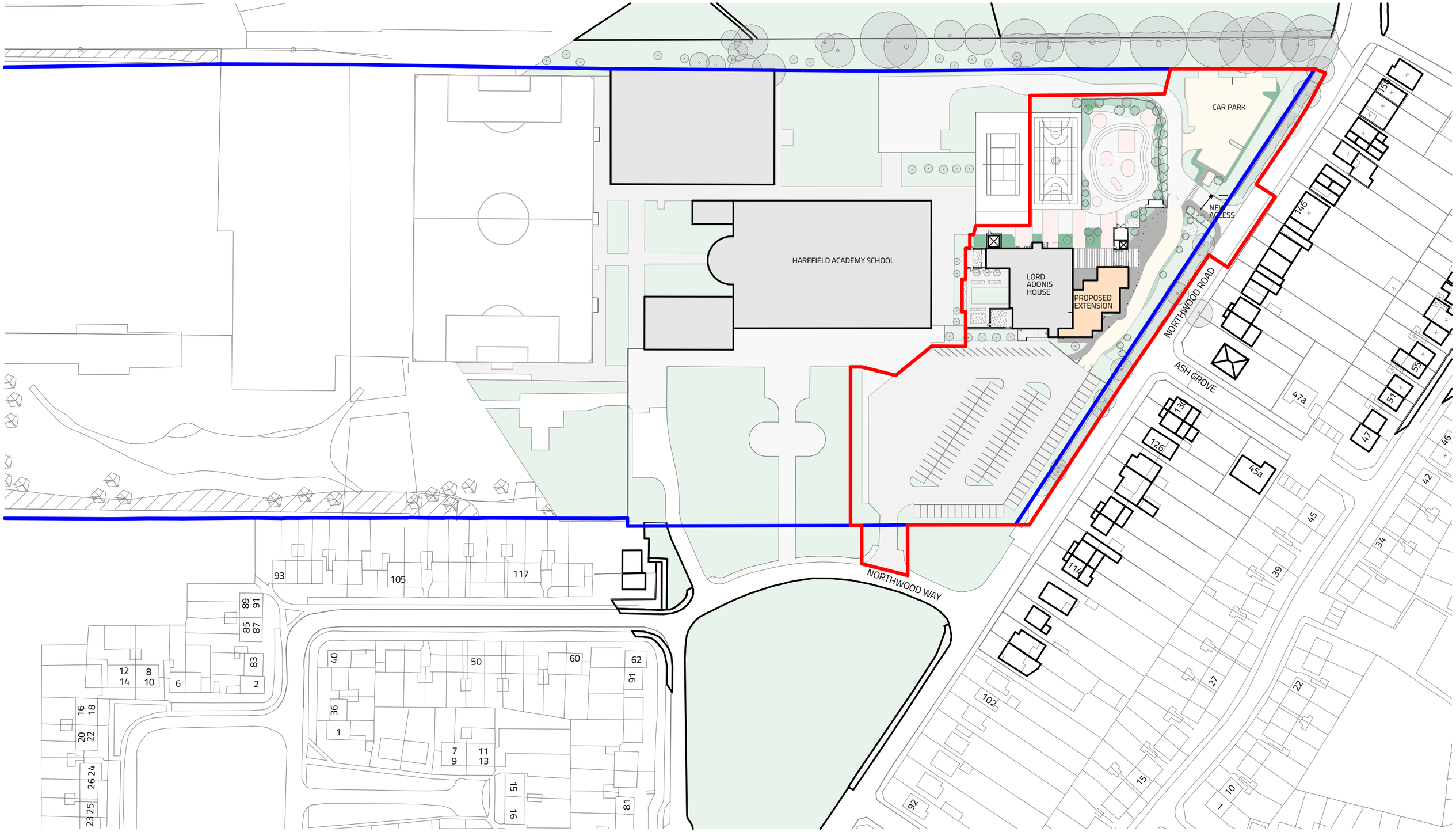
STONE, K., MURRAY, A., COOKE, S., FORAN, J. and GOODERHAM, L. 2009. Unexploded ordnance (UXO), a guide to the construction industry. CIRIA Report C681. Contaminated Land: Applications in Real Environments, London.

STROUD, M. A. 1975. The standard penetration test in insensitive clays and soft rocks. Proceedings of the European Symposium on penetration testing, 2, 367-375.

TOMLINSON. M.J. 2001. Foundation Design and Construction (6th Edition and 7th Edition). Prentice Hall Press

WASTE AND RESOURCES ACTION PROGRAMME (WRAP). October 2013. Quality Protocol. Aggregates from inert waste. End of waste criteria for the production of aggregates from inert waste.

Appendix A Drawings



A (GA) 001 **PROPOSED LOCATION PLAN**

SCALE 1:1250

0 25 50 75 100 125 METRE
PAPER SCALE 1:1250

NOTES:

N

Adjacent Ownership

Application boundary

Rev	Date	Issue
E	06/05/2022	FOR PLANNING
D	29/04/2022	FOR COSTING
C	13/04/2022	FOR INFORMATION
B	04/04/2022	Preliminary issue
A	25/02/2022	FOR INFORMATION

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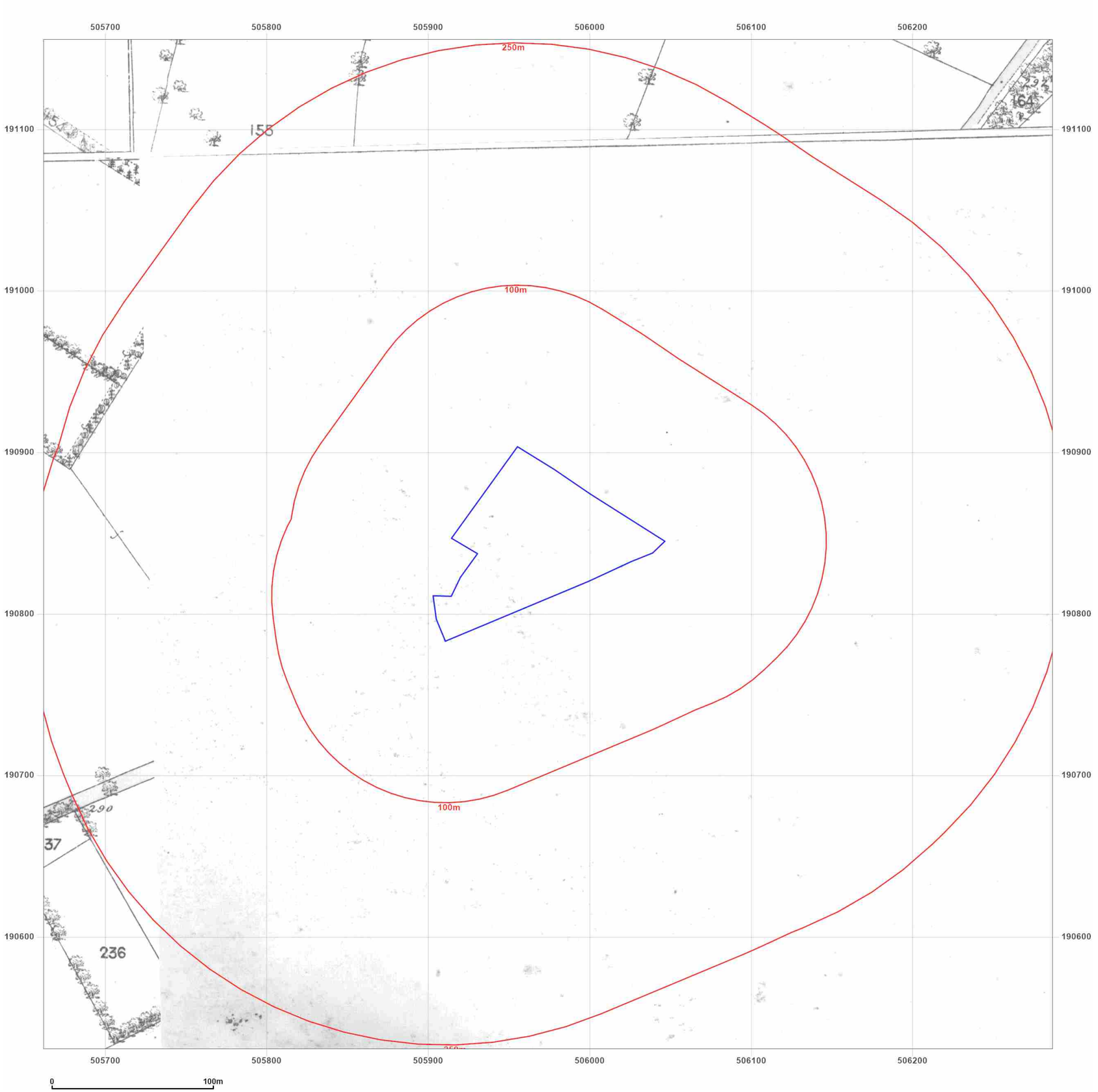
ADDRESS: Northwood Way, Harefield Uxbridge UB9 6ET

PROJECT: Harefield School Expansion

TITLE: **PROPOSED LOCATION PLAN**

DATE :	SCALE @ A3 :	PROJECT.	DRAWING NO.	REV :
06/05/2022	1:1250	4266 CDC XX 00 DR A	(GA) 001	E

Appendix B Historical ordnance survey maps



Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: County Series

Map date: **1865-1866**

Scale: 1:2,500

Printed at: 1:2,500

N
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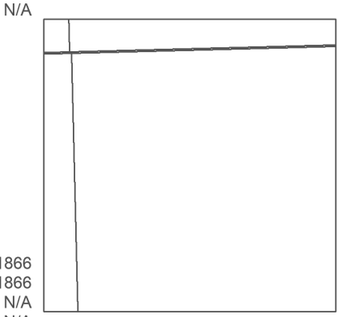
Surveyed 1865
Revised 1865
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1865
Revised 1865
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1866
Revised 1866
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1866
Revised 1866
Edition N/A
Copyright N/A
Levelled N/A

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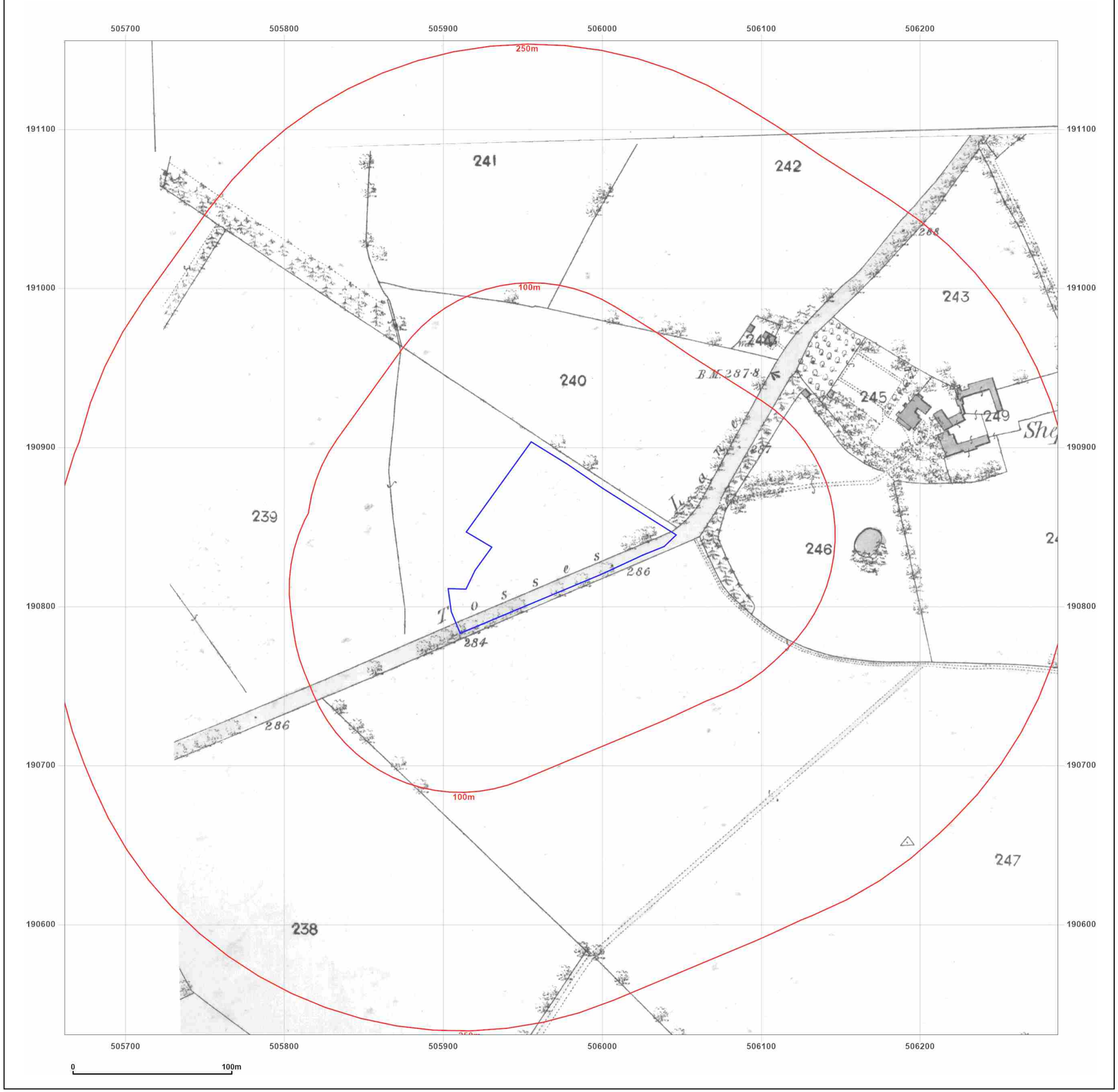

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: County Series

Map date: **1865-1866**

Scale: 1:2,500

Printed at: 1:2,500

N
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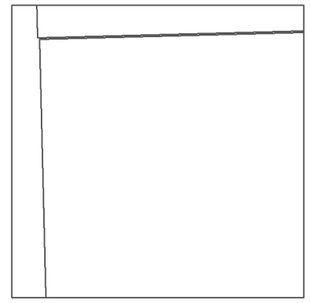
Surveyed 1865
Revised 1865
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1866
Revised 1866
Edition N/A
Copyright N/A
Levelled N/A

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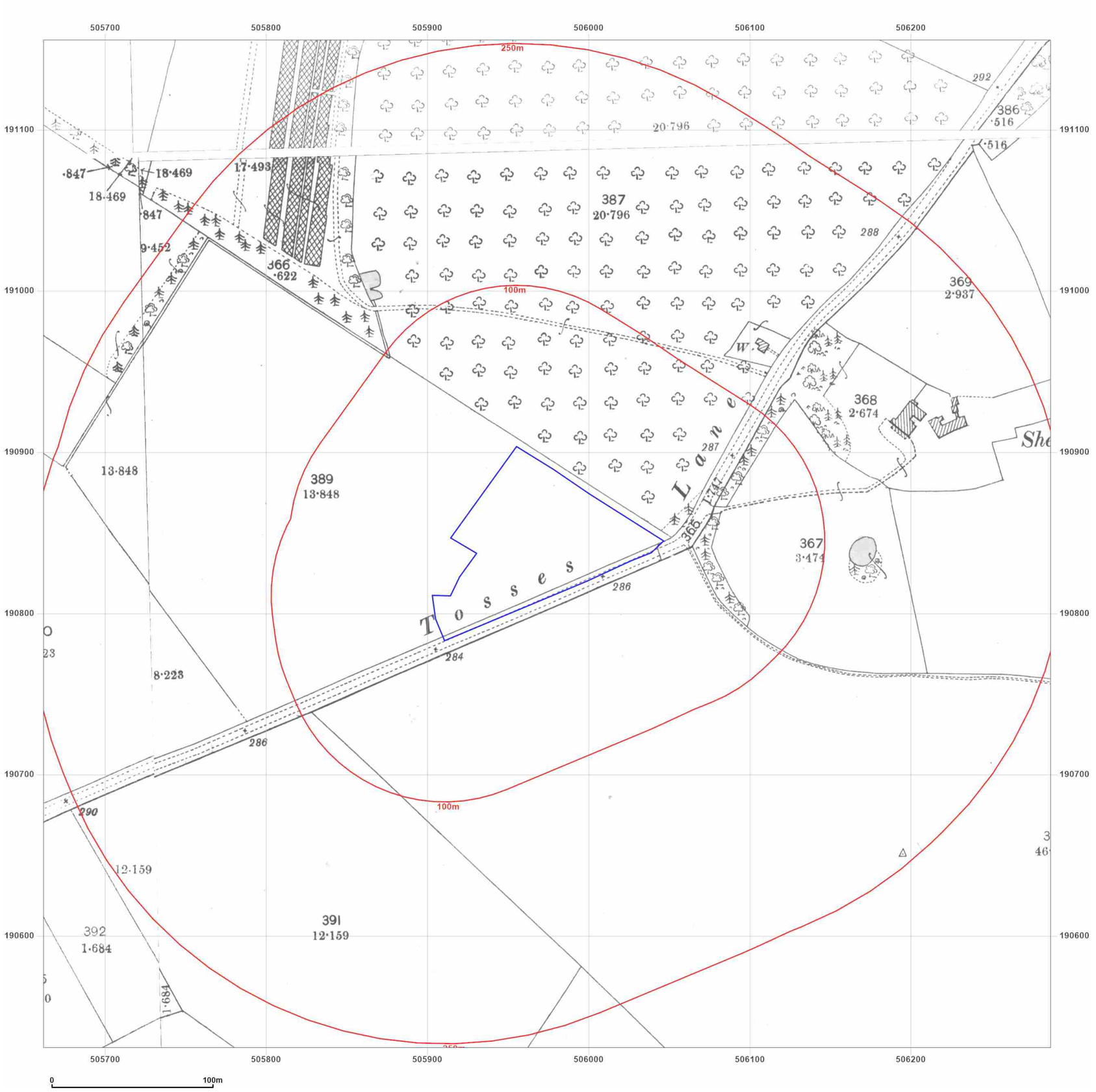

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: County Series

Map date: **1895-1896**

Scale: 1:2,500

Printed at: 1:2,500

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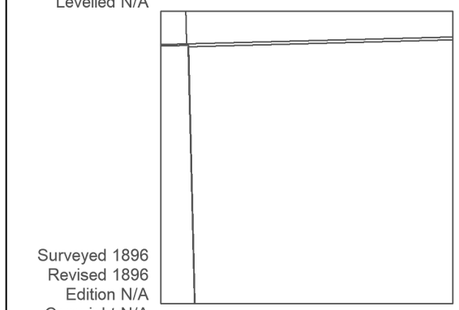

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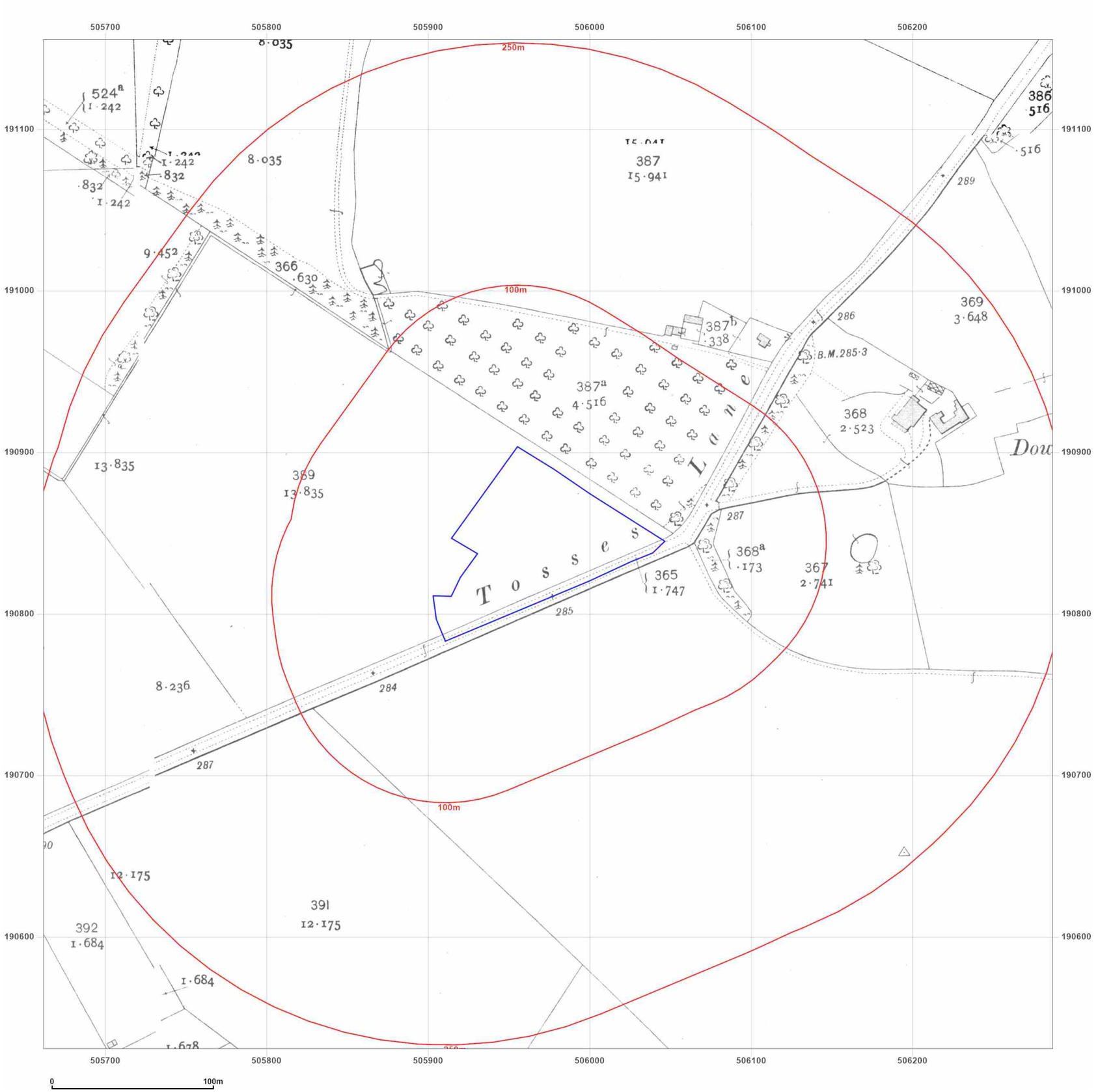

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: County Series

Map date: **1914**

Scale: 1:2,500

Printed at: 1:2,500

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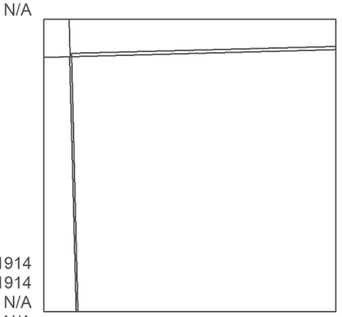
Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1871
Revised 1912
Edition 1914
Copyright N/A
Levelled N/A



Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
Levelled N/A

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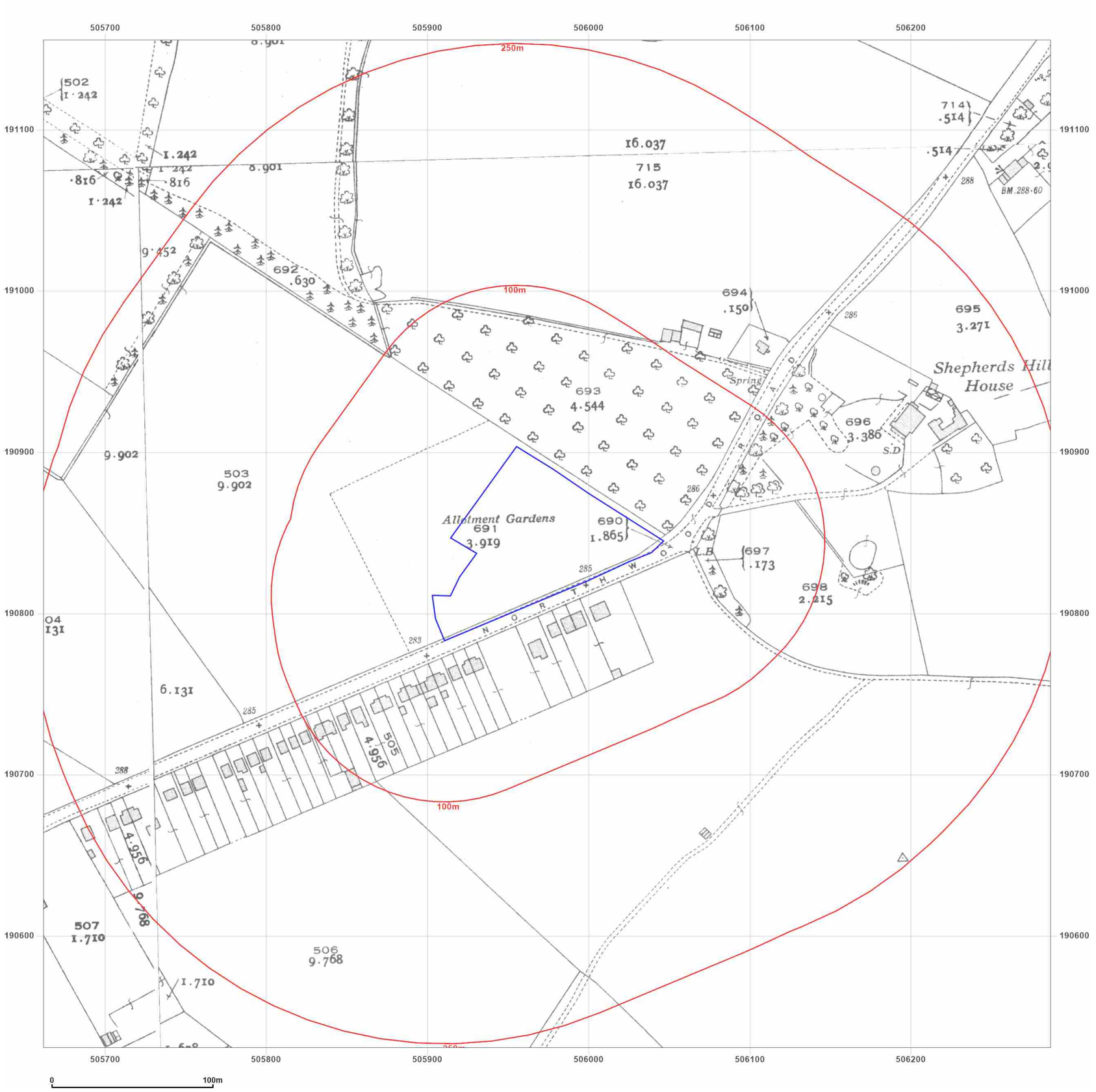

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: County Series
Map date: **1934-1935**
Scale: 1:2,500
Printed at: 1:2,500

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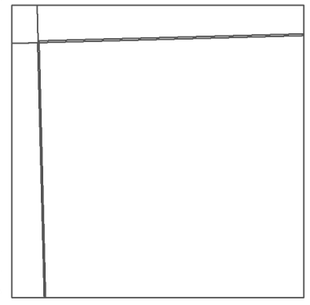
Surveyed 1934
Revised 1934
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1935
Revised 1935
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1934
Revised 1934
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1934
Revised 1934
Edition N/A
Copyright N/A
Levelled N/A

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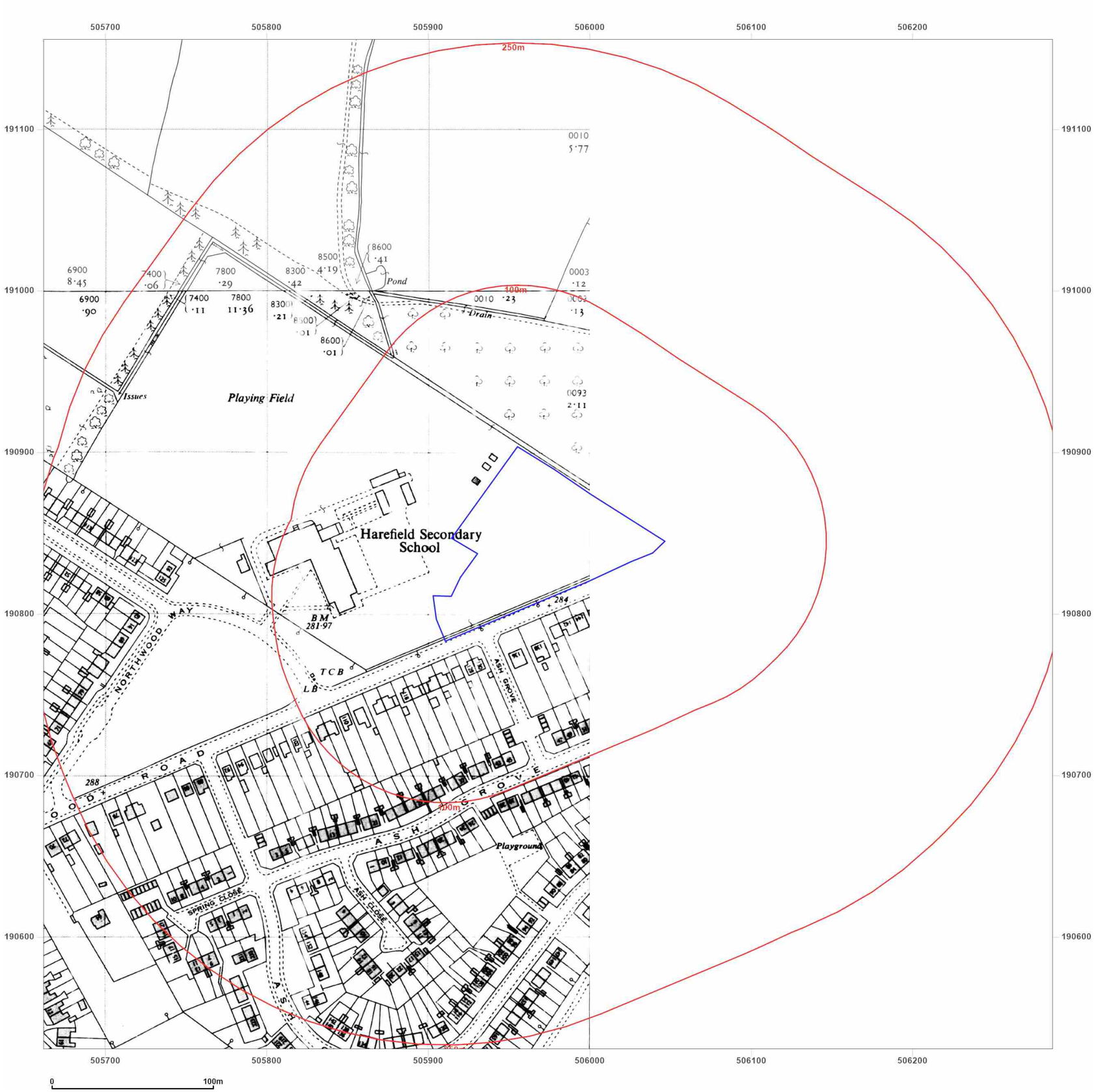

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: National Grid

Map date: **1960**

Scale: 1:2,500

Printed at: 1:2,500

N
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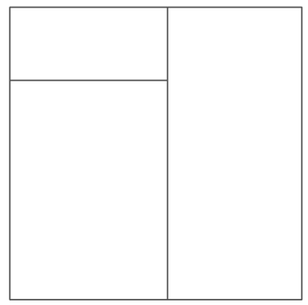
Surveyed 1959
Revised 1959
Edition N/A
Copyright 1960
Levelled 1957



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

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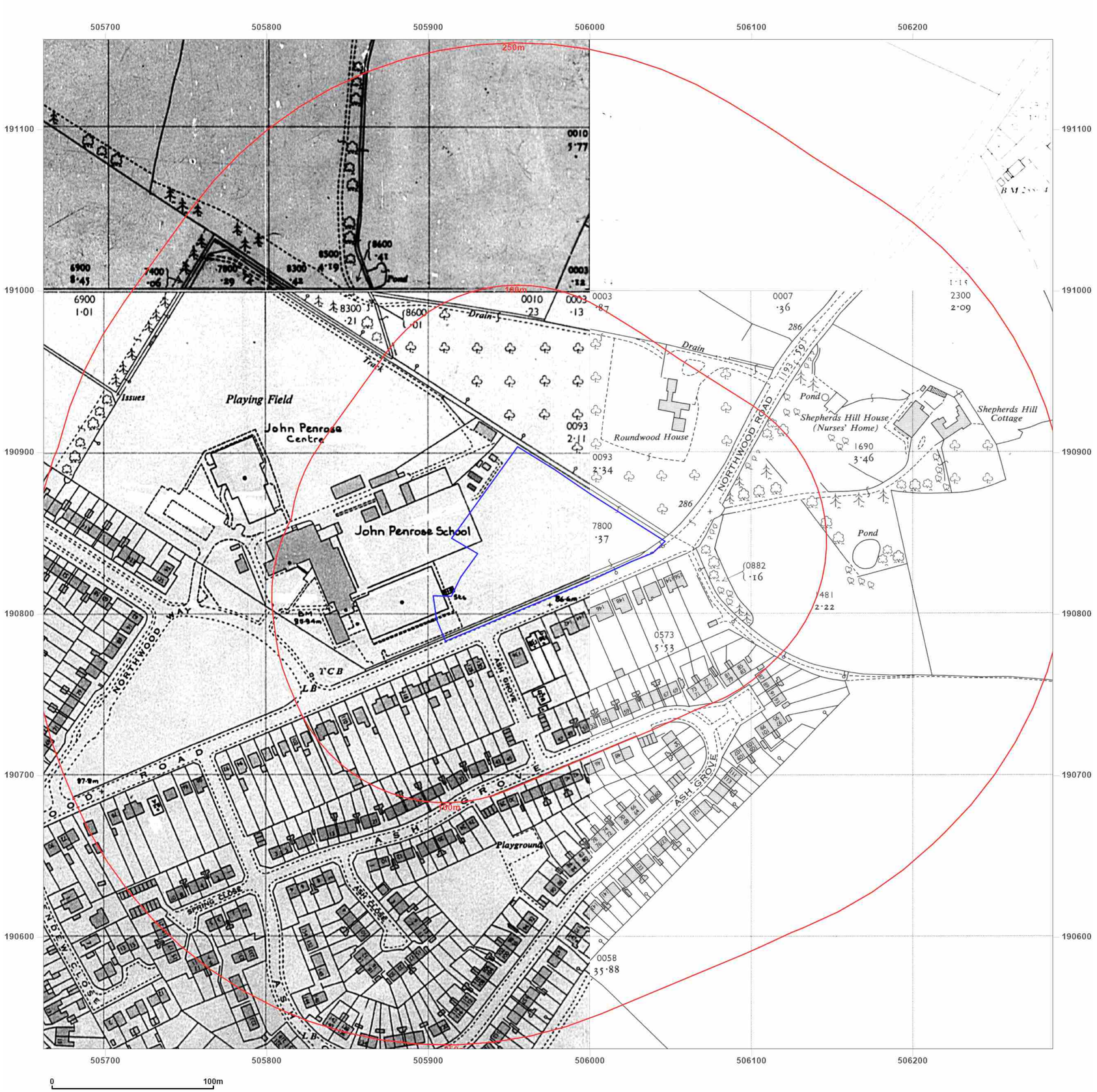

Groundsure INSIGHTS

Site Details:

505964, 190856

Client Ref: PO24657_27471-GELO
Report Ref: HYD-9412162
Grid Ref: 505974, 190843

Map Name: National Grid

Map date: **1956-1961**

Scale: 1:2,500

Printed at: 1:2,500

N
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Revised N/A
Edition N/A
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Levelled 1956

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

Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled 1957

Surveyed 1959
Revised 1959
Edition 1961
Copyright 1961
Levelled 1956

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