



LAGAN HOMES

BURROUGHS ROAD, RATBY

**GROUND INVESTIGATION
REPORT**

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22069-GE02B	Phase 2 Site Features Plan	1:1000 @ A0
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1. INTRODUCTION

1.1 Introduction

- 1.1.1 This report has been compiled in accordance with instructions received from Mr Stuart Pearson on behalf of Lagan Homes Limited and in accordance with proposals prepared by Travis Baker Geo-Environmental Ltd (TBGE) and issued by email on 14 July 2023.
- 1.1.2 This report has been prepared to provide an appraisal of ground conditions and identify potential development constraints in respect of a proposed development at Burroughs Road in Ratby. The Burroughs Road site forms Phase 2 of the West Ratby Expansion development. Drawing 22069-GE01A identifies the subject area for the this report (hereafter referred to as the 'site') in the context of the wider West Ratby Expansion, which is referred to hereafter as the 'wider site area'.
- 1.1.3 The appraisal of the site, documented in this report has been undertaken in accordance with the risk assessment framework presented in 'Land Contamination Risk Management (LCRM)' (Environment Agency, 2020). LCRM requires that a phased approach be followed to assess the risk of ground contamination. This phased approach involves the production of a 'preliminary risk assessment' (PRA), followed by an intrusive investigation and quantitative risk assessment, followed in turn by the design, implementation and verification of remedial works should any contaminants be found in unacceptable concentrations.
- 1.1.4 A Phase 1 Desk Study Report has been prepared for the site by TBGE (Phase 1 Geo-Environmental Assessment), dated 16 May 2022 (hereafter referred to as the Desk Study Report). The Desk Study Report includes a desk study and site reconnaissance, and is therefore compliant with a PRA.
- 1.1.6 The ground investigation works detailed in this report have been designed based on the Conceptual Site Model (CSM) included in the Desk Study Report.
- 1.1.7 The information contained within this report includes a site specific summary of the relevant historical, geological and environmental setting of the site and immediate area. A list of the information sources used in the preparation of this report are included in Appendix 1. TBGE have exercised reasonable care in examining and interpreting this information but cannot guarantee its authenticity.
- 1.1.8 The findings of this report are based on the ground conditions identified at the individual exploratory holes and the associated laboratory testing. TBGE have used reasonable skill and diligence in interpreting the conditions between the exploratory hole locations, however we do not accept any liability for conditions that are not revealed by the exploratory holes or test data. Our recommendations on the ground conditions between or beneath exploratory hole locations are therefore for general guidance only and should be confirmed at or prior to construction.
- 1.1.9 This report has been prepared for the sole internal use and reliance of Lagan Homes. This report shall not be relied upon or transferred to other parties without the written authorisation of TBGE.

2. SITE DETAILS

2.1 Site Location and Description

Site Location and Description

2.1.1 The site comprises an irregular shaped parcel of land located to the north west of the wider proposed development area in the west of Ratby, Leicestershire. The site lies to the south of Markfield Road and west of the Phase 1 development area, which is currently under construction. The site comprises approximately 4.7 hectares of undeveloped agricultural land approximately centred at national grid reference 450525, 306405. The site location is shown on Drawing No. 22069-GE01A.

2.1.2 A Travis Baker Engineer initially conducted a site walkover on 27 April 2022 as part of the preliminary risk assessment of the wider site area. As part of the ground investigation works carried out on 1 August 2023, a walkover of the site has been undertaken to reflect the current status of the site. The main site features observed are outlined in the following paragraphs and are illustrated on Drawing No. 22069-GE02B. A selection of photographs taken during the ground investigation are included as Appendix 3.

Site Walkover - April 2022

2.1.3 At the time of the site visit the site comprised two undeveloped agricultural fields designated Fields 5 and 8 on drawing 20040-GE02B that were planted with an unknown crop. The eastern boundary of Field 8 comprises a track and Heras fencing associated with car parking for the Phase 1 development of the site (situated to the north east). A public footpath (R50) intersects the north east of Field 5. In the western corner of Field 5, an electricity pylon is located with overhead cables trending north west off-site.

Site Walkover – August 2023

2.1.4 At the time of the second site visit in August 2023, the site comprised undeveloped grassland with areas of disturbed ground that are assumed to be associated with relatively recent archaeological trenches. The field boundary between fields 5 and 8 are defined by hedgerows together with infrequent trees. Access to the site is off Markfield Road from the north leading to a private road with gravel hardstanding that grades to a dirt track. The gravel hardstanding extends from the access road into an adjacent field to the north east. The area formerly in use as a parking area for the Phase 1 works (observed April 2022) is no longer present.

2.1.5 The site is bound by hedgerows to the north east, south east and south west together with an area of woodland to the north west and Markfield Road to the north.

2.1.6 The topography varies across the site from a high point of 111.3m AOD in the approximate centre of the site that gently slopes to the east, south and west to a low point of 100.1m AOD in the eastern corner of the site. We have included a copy of the topographic survey on Drawing No. 22069-GE02B.

2.1.7 No signs of potentially significant contamination were noted during the site walkover.

2.1.8 No invasive species (i.e. Japanese knotweed, Himalayan balsam or giant hogweed) were observed during the site walkover however; it should be noted that we are not ecological specialists and consultation with suitably qualified consultants will be required to confirm their absence.

2.1.9 The main features observed on the site and in the surrounding area are shown on Drawing No. 22069-GE02B; a selection of site photographs taken from the initial walkover (April 2022) and site works (August 2023) is included in Appendix 2.

3. PREVIOUS DESK STUDY REPORT

3.1 Overview

- 3.1.1 The following subsections present a brief summary of the main findings and conclusions of the Travis Baker Phase 1 Geo-Environmental Assessment dated 16 May 2022. This report should be read in conjunction with the Desk Study Report for supporting background information. Please note, the Desk Study Report was prepared for the wider site area therefore not all of the information is relevant to the proposed development area.
- 3.1.2 This section aims to summarise the pertinent findings of the Desk Study Report relevant to the site and supplement the summary with further updated background research from online sources. Subsequently, an updated site-specific Conceptual Site Model (CSM) has been prepared that is suitable for the site.

3.2 Site History

Site Area

- 3.2.1 Based on historic mapping, the site has generally comprised undeveloped agricultural land from the 1880's until the present day with the exception of the north of the site (Field 8) where allotment gardens were mapped between the 1920's to the 1990's.

Surrounding Area

- 3.2.2 From the 1880's the surrounding area comprised undeveloped agricultural land and mixed woodland to the north. Residential development began in the 1900's to the south west with successive construction mapped until the present day. Aerial photography from publicly available online sources suggest mixed woodland to the north west was seeded in the late 1990's.

3.3 Geology

- 3.3.1 The site is reported to be overlain by superficial materials comprising diamicton of the Thrussington Member. These deposits are variable in nature but typically comprise brown to reddish brown gravelly clay with sand and silt. The superficial deposits are recorded to be underlain by the Edwalton Member with the material comprising red brown and greenish grey mudstone and siltstone with beds of dolomitic siltstone and fine grained sandstone.

3.4 Hydrology and Hydrogeology

- 3.4.1 There is a stream recorded to the south west of the site. The stream flows to the south east and joins another stream to the south of the site. These streams are recorded to join Rothley Brook further to the south east of the site.
- 3.4.2 The Thrussington Member is classified as a Secondary A aquifer defined as '*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. These are generally aquifers formerly classified as minor aquifers.*'
- 3.4.3 The underlying Edwalton Member is classified as a Secondary B aquifer defined as '*Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.*'
- 3.4.4 The site does not lie within a designated Groundwater Source Protection Zone (SPZ).

- 3.4.5 The Government's online Flood Map for Planning and the Groundsure report indicate that the site lies within 'Flood Zone 1' which means there is a low probability of flooding from rivers across the site.

3.5 Mining

- 3.5.1 The site lies outside of a Coal Mining Reporting Area therefore a Coal Mining report is not required for the site. Based on the underlying geology, the site is not considered to be at risk as a result of past underground coal mining.

3.6 Radon

- 3.6.1 It should be noted that the 'UKHSA-BGS Indicative Atlas of Radon in the United Kingdom' was updated on 1 December 2022 prior to the production of the Desk Study Report. The updated guidance indicates that radon potential has changed and is now categorised between 1% to 3% in this area. However, the recommendations have not changed and new properties constructed on the site will not require radon protective measures.

3.7 Landfill / Waste Sites

- 3.7.1 There are no active or historic landfill sites, waste treatment, transfer or disposal sites within 500m of the site (or wider site) boundary.

3.8 Services

- 3.8.1 Service information has been provided to us by Lagan Homes in April 2022. In addition, we have undertaken web-based service searches of utility providers for the site and surrounding area in July 2023 prior to the intrusive works. Aside from the electricity pylon in the west corner of the site (for which the connecting cables trend offsite), there are no water, gas or drainage services recorded on site.
- 3.8.2 The approximate locations of the known services are shown on Drawing No. 22069-GE02B.

3.9 Unexploded Ordnance

- 3.9.1 An Unexploded Ordnance (UXO) risk map produced by Zetica indicates that the risk of encountering UXO associated with World War II bombing raids beneath the site is 'low'. It should be noted that the risk map is drawn based on the bombing density of an area and does not take into account the specific historical use of the site during WWII therefore the possibility of encountering UXO cannot be completely discounted. However, based on the general absence of development on the site and lack of specific targets in the general area, the bomb risk is not considered to be elevated when compared with similar development projects.

3.10 Initial Conceptual Site Model

- 3.10.1 An initial Conceptual Site Model (CSM) is reported in the Desk Study Report, the relevant site specific points have been reproduced and it has been updated as necessary below. It incorporates the accepted 'Source-Pathway-Receptor' linkage ('contaminant linkage') approach outlined in Part 2A of the Environmental Protection Act 1990. In order for a contaminant linkage to exist, a source, pathway and receptor must all be present. Land Contamination Risk Management (LCRM) (Environment Agency, 2020) defines these elements as follows:

- **Source** – a contaminant or pollutant that is in, on or under the land and has the potential to cause harm or pollution

- **Pathway** – a route by which a receptor is, or could be affected by a contaminant
- **Receptor** – Something that could be adversely affected by a contaminant. Examples include humans, controlled waters, ecosystems and Part 2A receptors such as buildings, crops or animals.

3.10.2 LCRM expressly states that “without a contaminant linkage, there is not a risk – even if a contaminant is present”.

3.10.3 The aim of the CSM is therefore to provide a qualitative assessment of the risk posed to both human health and environmental receptors from potential on-site and off-site sources of ground contamination. Sections 3.11 to 3.13 below summarises the potential sources, pathways and receptors identified.

3.11 Potential Sources

3.11.1 Table 1, below, lists the remaining potential sources of ground contamination identified at the site and in the surrounding area, together with the contaminants that have the potential to have been generated. Contaminants arising from both current and historical land uses have been considered, and have been separated according to whether they are likely to have originated from within the development area or from other on-site or off-site source activity.

3.11.2 Table 1 below shows a visual representation of the CSM, an illustration of the relevant site features in respect to the site are shown on Drawing 22069-GE02B.

Table 1 – Initial Conceptual Site Model

	Source	Potential Contaminant
<i>On-Site</i>		
1	Possible infilling of natural hollows etc associated with farming activities	Asbestos, heavy metals, metalloids, polyaromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH)
2	Former allotment gardens in the north east	Organophosphorus pesticides, organochlorine pesticides, lead-/arsenic-based pesticides including lead arsenate
3	Historical use as farmland	Organophosphorus pesticides, organochlorine pesticides, total petroleum hydrocarbons (TPH), lead-/arsenic-based pesticides including lead arsenate)
4	Possible localised near-surface made ground associated with use as former compound / parking area (associated with Phase 1)	Polyaromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH)
<i>Off-Site</i>		
5	Historical use as farmland	Organophosphorus pesticides, organochlorine pesticides, total petroleum hydrocarbons (TPH), lead-/arsenic-based pesticides including lead arsenate)

3.12 Potential Pathways

3.12.1 The list below summarises possible pathways, which could allow potential receptors to be exposed to any contamination present at the site:

- Dermal contact, ingestion or inhalation of soil contaminants by site users;
- Ingestion of contaminated soil and soil-derived dust;
- Inhalation of contaminated dust;
- Migration of contaminants via service routes and foundations;
- Direct contact between contaminated soils and building substructures;
- Leachate migration into pore water from soil contamination, followed by dilution and dispersion through soils into groundwater.

3.13 Potential Receptors

3.13.1 Potential receptors to any contamination identified at the site include:

- Humans –construction workers and subsequent site users;
- Proposed development – buildings, substructures, flora and fauna;
- Controlled waters – ‘Secondary A’ classification of superficial soils beneath the site, ‘Secondary B’ aquifer classification of Edwalton Member bedrock geology;

3.13.2 There are no major ecological receptors recorded within a 1km radius of the site.

3.14 Preliminary Geotechnical Assessment

3.14.1 The superficial geology indicated by the BGS ‘Geoindex’ data (Thrussington Member) could potentially provide suitable bearing strata for conventional shallow foundations supporting lightly-loaded structures. However, foundation choice has the potential to be affected by the volume change potential of clay soils (particularly if present in the vicinity of existing or former trees). The ground investigation works need to provide geotechnical data for the proposed development, including an assessment of suitable foundation options for the proposed dwellings.

3.15 UXO

3.15.1 The online risk map maintained by Zetica UXO has been reviewed to determine the risk of unexploded ordnance at the site in relation to WWII. The map indicates the site to have a low bomb risk of 1% across the site and surrounding area although it indicates there was industry nearby to the west.

3.15.2 Although the site does not appear to pose an increased risk of UXO encounters when compared with similar sites, it is recommended that prior to any development a preliminary UXO risk assessment should be obtained, in line with current best practice.

4. DETAILS OF GROUND INVESTIGATION

4.1 Ground Investigation Strategy

4.1.1 The TBGE ground investigation was undertaken on 1 August 2023 and comprised the following works:

- 8 mechanically excavated trial pits (TP01 to TP08);
- 5 mechanically excavated shallow trial pits (HP01 to HP05);
- 6 dynamic cone penetrometer tests (DCP1 to DCP6);
- Geochemical and geotechnical laboratory analysis of soil samples.

4.1.2 The ground investigation was designed to provide a series of non-targeted sampling points to obtain a general spread of information across the proposed development area. All exploratory holes are to investigate any potential ground contamination and geotechnical risks identified in the initial CSM. Table 2 presents a summary of the ground investigation strategy:

Table 2 - Ground Investigation Strategy

Ref.	Objective
All exploratory holes	To investigate the nature and depth of any topsoil/made ground, any near surface superficial deposits and underlying strata.
Machine excavated trial pits (TP01 to TP08)	To investigate the stability of the near surface materials, the characteristics of the groundwater and obtain samples of the recovered material. Undertake hand shear vane tests within the undisturbed cohesive strata to 1.0m and suitable arisings below 1.0m to determine the consistency of the cohesive materials.
Hand excavated trial pits (HP01 to HP05)	To investigate the nature and depth of the topsoil and any near surface superficial deposits and allow collection of samples for laboratory chemical testing.
Dynamic Cone Penetration (DCP) tests (DCP1 – DCP6)	To obtain data for CBR equivalency values for road design.
Laboratory testing (contamination)	Analysis of soil samples to enable a quantitative assessment of the potential risks identified in the CSM.
Laboratory testing (geotechnical)	Analysis of soil samples to assist with foundation design.

4.1.3 The number and spacing of non-targeted sampling points across the site was generally compliant with that recommended by BS10175:2011+A2,2017 '*Investigation of potentially contaminated sites – Code of practice*' for a 'main investigation'.

4.1.4 The following subsections describe the investigation in additional detail. The locations of the exploratory holes are shown in Drawing No. 22069-GE03.

4.2 Investigation Methodology

4.2.1 All of the ground investigation fieldwork was undertaken under the direction of a TBGE engineer.

Underground Services Avoidance

- 4.2.2 Prior to the commencement of each trial pit and DCP each location was checked against the available service records. Further checks were made by the TBGE Engineer using a Cable Avoidance Tool (CAT) at each location.
- 4.2.3 Trial Pits TP01 to TP08 were dug using a mechanical excavator supplied by Colden Plant Hire, to depths of between 2.2m and 3.5m. After detailed examination, measurement and sampling the pits were backfilled with arisings and nominally compacted with the machine bucket to minimise (as far as possible) the risk of post-reinstatement settlement. HDP01 to HDP05 were excavated by hand to depths of between 0.4m and 0.5m to record the thickness of topsoil, nature of the underlying soils and allow collection of samples for laboratory testing.

Soil Sampling

- 4.2.4 Samples of the soil arisings recovered from the trial pits were collected by a TBGE Engineer. The guidance in BS10175:2011+A2,2017 '*Investigation of potentially contaminated sites – Code of practice*' was followed during the recovery of samples for chemical analysis. All samples were collected using a stainless-steel trowel, which was cleaned prior to the collection of each sample. The samples were stored in new clean containers (plastic tubs or amber jars, as appropriate to the laboratory analysis) and transported to the laboratory in insulated, refrigerated cool boxes under complete chain of custody documentation.

Records of Fieldwork

- 4.2.5 Detailed records of the trial pits have been produced in accordance with BS5930:2015+A1,2020 '*Code of practice for ground investigations*' and are included in Appendix 3. Photographs of the trial pits are included in Appendix 3.

4.3 Laboratory Testing

Chemical Testing

- 4.3.1 Selected soil samples were subjected to laboratory tests for a range of contaminants, as identified by the CSM in the Sections 3.11 to 3.13 above and also taking account of observations made during the fieldwork. Table 3 summarises the laboratory tests performed.

Table 3 - Contamination Laboratory Tests Performed on Soil Samples

Test	Topsoil	Edwalton Member
Travis Baker Greenfield Suite (◇)	12	12
USEPA16 Polyaromatic Hydrocarbons (PAHs) (#)	10	-
Total Organic Carbon	-	5
Asbestos screen	4	-
Pesticides	3	-
pH and water soluble sulphate	-	21

Notes on Table 3:

(◇): Travis Baker Greenfield suite includes: - arsenic, boron, cadmium, total chromium, copper, lead, mercury, nickel, selenium, zinc, phenol, sulphate (soluble), pH (Brownfield suite includes cyanide, beryllium, chromium VI and vanadium).

(#): USEPA16 PAH includes:- naphthalene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, benzo(ghi)perylene and dibenzo(a,h)anthracene.

5. GROUND CONDITIONS

5.1 Succession of Strata

- 5.1.1 The general succession of the underlying substrata comprises a surface covering of topsoil, typically overlying naturally occurring clay grading to interbedded clays further grading to interbedded mudstone and sandstone of the Edwalton Member.

5.2 Topsoil

- 5.2.1 Ploughed topsoil is encountered across the majority of the site (Field 5) comprising dark brown slightly sandy to sandy clay with rare rootlets. Localised constituents of gravel of chert and sandstone are recorded in TP06.
- 5.2.2 Topsoil is recorded in HP03 and HP04 in field 8 comprising black and dark brown sandy clay.

5.3 Natural Soils

Superficial Deposits

- 5.3.1 No materials considered representative of the recorded Thruslington Member were recovered across the site.

Edwalton Member

- 5.3.2 Beneath the topsoil, materials comprising orangish / reddish brown, light brown and light grey slightly sandy to sandy clay is found interbedded with silty very sandy clay and slightly sandy gravelly to very gravelly clay with variable proportions of mudstone, siltstone and sandstone lithorelicts, typically increasing with depth. Locally rare bands of cemented silty sand and sandstone are present. These materials are considered representative of weathered strata of the Edwalton Member.
- 5.3.3 Typically, the majority of trial pits TP01 and TP03 to TP08 were terminated at depths of between 1.9m to 3.4m on mudstone and sandstone attributed to the Edwalton Member.
- 5.3.4 At this stage, based on the ground conditions encountered, it is considered that there may be several thin bands of 'hard strata' encountered which may not be representative of bedrock and further bands of weathered materials (clays and sands) may potentially be present at greater depth.

5.4 Groundwater

- 5.4.1 During the fieldwork, groundwater was encountered in a single trial pit, TP01 at 3.0m, within sandstone of the Edwalton Member; all of the remaining trial pits remained dry.
- 5.4.2 Groundwater levels have the potential to fluctuate throughout the year and between years due to the dynamic balance between groundwater recharge, storage and discharge.

5.5 Stability

- 5.5.1 All of the exploratory holes remained stable for a short period following excavation. It is considered that excavations for conventional strip or trench fill foundations are unlikely to require support in the short term however, trench support should be provided for excavations requiring person entry or any excavation greater than 1.0m.

6. GROUND CONTAMINATION ASSESSMENT

6.1 Assessment Methodology

- 6.1.1 The ground contamination has been undertaken using a risk-based approach and incorporating the accepted 'contaminant linkage' approach.
- 6.1.2 The detailed assessment of ground contamination at the site has followed the tiered approach adopted in LCRM and presented below:
- **Preliminary risk assessment** – Development of a CSM, presenting the identified contaminant linkages at the site
 - **Generic quantitative risk assessment** – Selection of appropriate Generic Assessment Criteria (GAC) and comparison to the measured contaminant concentrations
 - **Detailed quantitative risk assessment** – Derivation of Site-specific Assessment Criteria (SSAC), if the measured contaminant concentrations exceed the respective GAC.

6.2 Preliminary Risk Assessment

- 6.2.1 An initial CSM is presented in Sections 3.10 to 3.13 of this report.
- 6.2.2 The ground conditions generally comprise topsoil overlying clays of the Edwalton Member grading to interbedded mudstone and sandstone. Groundwater was encountered at 3.0m at one location during the ground investigation; all other trial pits are recorded dry.
- 6.2.3 No visual or olfactory evidence of potentially significant contamination was recorded during the ground investigation.

6.3 Generic Quantitative Risk Assessment: Long-term Human Health (Future Site Users) and Proposed Development End Use

- 6.3.1 The risk to long-term human health has been assessed using a combination of published GAC for a residential development end use with homegrown produce. This is considered appropriate for the proposed development of residential housing with an associated garden area.
- 6.3.2 The contamination laboratory test results (included in Appendix 4) have been compared directly to GAC obtained from the following sources (listed in order of preference):
- Category 4 Screening Levels (C4SL). LCRM specifies that these should be used in preference to other published GAC where available
 - Suitable for Use Levels (S4UL) published by the Chartered Institute of Environmental Health (CIEH) and Land Quality Management (LQM)¹

The GAC adopted for this assessment are tabulated in Appendix 7.

¹ S4ULs have been used in accordance with the following: "Copyright Land Quality Management Ltd reproduced with permission; Publication number S4UL3689. All rights reserved".

- 6.3.3 Where appropriate, a soil organic matter (SOM) content of 1% has been conservatively assumed.
- 6.3.4 A summary table, which includes comparisons of the concentrations of each determinant measured by the laboratory tests to the respective GAC is included in Appendix 4. This indicates that the maximum detected concentrations of all of the tested determinants were below the respective GAC.

- 6.3.6 No fragments or fibres of asbestos were detected in any of the soil samples tested.
- 6.3.7 Three samples of topsoil were sent for organochlorine (OCP) and organophosphate (OPP) pesticide suites, all determinands are below the laboratory limit of detection.
- 6.3.8 On the basis of the foregoing, it is considered that the levels of contamination across the site are within acceptable limits for retention without presenting an unacceptable risk of harm to the long-term health of future site users; remedial works with respect to contamination issues will therefore not be required.
- 6.3.9 The site won top soil and sub soil materials will therefore be suitable for re-use within the proposed garden and landscape areas.

6.4 Generic Quantitative Risk Assessment: Short-term Human Health (Construction Workers)

- 6.4.1 The contamination test results do not indicate any element or compound of specific concern with respect to the short-term health of construction workers. Therefore, the use of normal site PPE consisting of overalls, gloves and protective footwear is generally considered appropriate to mitigate any potential short-term risk of exposure by construction workers to soil contamination at the site.
- 6.4.2 A Health and Safety Hazard Assessment for the detailed undertakings should be undertaken as stipulated under the Construction Design and Management (CDM) Regulations 2015, with due regard to the laboratory test results presented in Appendix 4 and also identifying procedures for dealing with any unforeseen hazardous conditions. A Working Health and Safety Plan should be prepared, which mitigates the potential risks to site workers from the specific undertakings as identified in the Hazard Assessment.

6.5 Generic Quantitative Risk Assessment: Controlled Waters

- 6.5.1 Groundwater was encountered at 3.0m at one location during the ground investigation. No risk to groundwater was identified in the CSM. The ground investigation revealed the site is generally underlain by relatively impermeable clays and no determinands tested within the soils are recorded above the relevant GAC. On the basis of the foregoing it is considered the risk to groundwater is very low therefore no further action is required in this regard.

6.6 Ground Gas

- 6.6.1 The initial CSM did not identify any potential sources of ground gas that were considered to represent a risk to construction workers or the end users of the site. The subsequent ground investigation confirmed the site comprises natural clays grading to interbedded mudstone and sandstone associated with the Edwalton Member. There was no evidence of any made ground, organic rich soils or potential vapour sources. Total organic carbon tests undertaken on the Edwalton Member recorded concentrations of between <0.1% to 0.2%. On this basis the natural clays are not considered to be a significant source of ground gas.
- 6.6.2 Based on the CL:AIRE Research Bulletin RB17 '*A Pragmatic Approach to Ground Gas Risk Assessment*' the site can be classified with the framework presented in CIRIA Report C665 (2007) as a characteristic situation 1 (CS1). On this basis ground gas protection measures are not considered necessary. This should be confirmed with the local authority / NHBC prior to construction.
- 6.6.3 The site is not located within an area that requires radon protection measures.

7. GEOTECHNICAL ASSESSMENT

7.1 In-Situ Testing

Hand Shear Vane Tests

- 7.1.1 Hand Shear Vane Tests (HSV's) were undertaken within the fine ground soils identified within trial pits. The individual HSV values are provided on the trial pit logs and are summarised in Table 4, below.

Table 4 – Summary of Hand Shear Vane Tests

Location	Depth (m)	Hand Shear Vane Results (kPa)				Consistency
		HSV 1	HSV 2	HSV 3	Average HSV	
TP01	0.9	124	94	106	108	Stiff
TP02	0.8	119	96	82	99	Stiff
	1.6	46	60	50	52	Firm
	1.8	42	59	40	47	Firm
TP03	0.7	81	91	83	85	Stiff
	2.1	82	70	76	76	Firm / Stiff
TP04	0.9	108	99	96	101	Stiff
	1.9	103	100	101	101	Stiff
TP05	0.8	94	79	128	95	Stiff
TP06	0.8	94	91	73	86	Stiff
TP07	0.8	81	94	100	92	Stiff
TP08	0.8	82	90	90	87	Stiff

- 7.1.2 The HSV results for the weathered Edwalton Member clays indicate an average shear strength of between 47kPa to 108kPa (firm to stiff).

7.2 Laboratory Geotechnical Testing

Natural Water Content and Plasticity Index

- 7.2.1 Measurements of the natural moisture content and Atterberg Limits have been carried out on five samples of clay soils taken from trial pits. The results are included as Appendix 5 and summarised in Table 5, below.

Table 5 – Summary of Laboratory Plasticity Index Test Results

Location	Depth (m bgl)	Plasticity Index % (Ip)	Modified Plasticity Index % (I'p)	Volume Change Potential
TP01	1.7	12	12	Low
TP03	2.2	15	13	Low
TP04	1.0	16	15.4	Low
TP05	1.3	29	21.2	Medium
TP08	1.5	19	18.6	Low

- 7.2.2 The results of the laboratory testing indicate that the test soil have a modified plasticity index of 12% to 21% (i.e. low to medium volume change potential).

Particle Size Distribution Tests

- 7.2.3 Measurements of the particle sizes of selected samples have been carried out on three samples of natural material. The results are included as Appendix 5.
- 7.2.4 The results indicate that the natural strata comprises a grading of 28% to 44% clay, 16% to 51% silt and 9% to 56% sand. The particle size distribution tests indicated a higher portion of silt sized particles than identified during the field tests suggesting the natural strata behaves as a clay. Further analysis of the silt portions indicates the natural materials comprise a higher portion of medium to coarse grained silt than fine to medium grained silt. Therefore, the observed friability and lower shear strength in disturbed strata may be attributed to this faction.

7.3 Buried Concrete Classification

- 7.3.1 Measurements of the water-soluble sulphate content and pH-values have been made for twenty three samples of natural soils and eleven of topsoil recovered from across the site. The water soluble sulphate contents ranged between 5mg/l and 199mg/l. In accordance with the recommendations of BRE Special Digest 1 (3rd Edition, 2005) the soil can be designated a Design Sulphate Class of DS-1.
- 7.3.2 The measured pH values ranged between 6.8 and 8.6 that indicates an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1.

7.4 Hard Strata

- 7.4.1 Bands of extremely weak sandstone are present at depths between 0.7m and 2.0m and were fully penetrated using a JCB 3CX. Hard strata comprising interbedded mudstone and sandstone are encountered between 1.8m and 3.3m at the base of the trial pits. However, the trial pits designated TP06 to TP08 were terminated between 1.9m and 2.5m on very weak sandstone.
- 7.4.2 Based on the results of the trial pit investigation, it is considered the uppermost 2.0m of soils beneath the site should generally be achievable with similar plant to a JCB 3CX or larger. Should there be a requirement to excavate deeper than 2m then specialist plant may be required to achieve the target depth.

7.5 Founding Horizon

- 7.5.1 The topsoil is not considered an appropriate horizon for direct founding.
- 7.5.2 The near surface ground conditions encountered generally comprise firm to stiff clay of the weathered Edwalton Member. It is considered that these soils will generally be suitable for standard strip and trench fill foundations for the proposed 2 and 2½ storey residential housing. Consideration will need to be given to the depth of founding in the presence of trees.
- 7.5.3 Foundation options are discussed in further detail in Section 8 of this report.

7.6 Soakaway Drainage Potential

- 7.6.1 The ground investigation revealed predominantly fine-grained soils grading to interbedded mudstone and sandstone. The fine soils are generally considered to be of very low permeability and unlikely to be suitable for soakaway drainage. The interbedded mudstone and sandstone present at a depth of 2.0m is also considered unlikely to be sufficiently permeable for soakaway drainage due to the ratio of weathered mudstone. Groundwater was encountered at 3.0m at one

location within the sandstone. Based on the foregoing these materials are unlikely to be suitable for soakaway drainage.

7.7 Highways

7.7.1 Six dynamic cone penetration tests (DCPs) were undertaken across the proposed development area at depths of up to 0.9m to provide a CBR equivalency value for future road design.

7.7.2 The results are provided in Appendix 6 and summarised in Table 6, below.

Table 6 – Summary of Estimated CBR Values from DCPs

Location (depth below surface)	Estimated CBR Value (%)
DCP1 (0.05 to 0.31)	6.6
DCP1 (0.31 to 0.59)	32
DCP1 (0.59 to 0.87)	13
DCP2 (0.03 to 0.32)	3.3
DCP2 (0.32 to 0.87)	7.7
DCP3 (0.03 to 0.16)	3.5
DCP3 (0.16 to 0.85)	7.2
DCP4 (0.03 to 0.87)	11
DCP5 (0.27 to 0.59)	9.4
DCP5 (0.59 to 0.86)	12
DCP6 (0.14 to 0.87)	9.3

7.7.3 The results of the DCP testing provide estimated CBR values of between 3.3% and 32% between existing ground level and 0.9m below.

7.7.4 In-situ CBR testing will need to be carried out at the formation level to confirm the CBR values of the near surface soils and confirm the highway construction.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Potential Development Constraints

8.1.1 Based on the findings of the ground investigation works documented in this report, it is considered that the following issues relating to ground contamination, geotechnical considerations and other potential development constraints will need to be addressed prior to redevelopment of the Burroughs Road, Ratby site:

- The presence of fine soils of medium volume change potential within the weathered Edwalton Member beneath the site;
- Presence of sandstone bands at various depths within clay soils in the weathered Edwalton Member;
- Variable CBR tests;
- Near surface soils unlikely to be suitable for soakaway drainage.

8.1.2 Each of these issues is discussed in further detail below.

8.2 Foundations

8.2.1 Underlying the topsoil materials the ground conditions generally comprise firm to stiff clays attributed to the weathered Edwalton Member with bands of sand and sandstone. Groundwater was encountered at 3.0m in one trial pit during the ground investigation and all other trial pits remained dry.

8.2.2 It is recommended that an allowable bearing pressure of 150kN/m² is used for initial design purposes for shallow strip / trench fill foundations founding on the weathered Edwalton Member to limit total settlements to less than 25mm. All strip / trench fill foundations should extend a minimum of 0.9m below ground level (both existing and proposed ground level - whichever is deeper) based on the presence of medium volume change potential clays. All foundations should extend a minimum of 0.2m into undisturbed competent material. In areas of potential tree influence, foundations should be extended in accordance with Chapter 4.2 of the NHBC Standards. Localised heave protection measures are also likely to be required.

8.2.3 It is considered unlikely that shallow groundwater will be an issue during excavation of foundations up to 2.5m. If localised seepages are encountered, these should be able to be managed by sump pumping.

8.2.4 Due to the variable nature of the weathered Edwalton Member overlying the site, there is the potential for a combination of clay, sand and sandstone based materials to be present within the base of future foundation excavations. To accommodate any minor settlement between the clay and sand fractions the groundworker could either:

- i. Extend the foundation deeper in parts to ensure the whole foundations lies on a consistent soil type, or;
- ii. Provide a layer of mesh reinforcement (say B385) across the join of the two material types (to be confirmed by a structural engineer).

8.2.5 Alternatively if there are frequent changes in the nature of the soils at founding level the foundation designs could include light mesh reinforcement (say, B385) across the whole foundation to accommodate any potential minor differential settlement between cohesive and granular fractions.

- 8.2.6 If any made ground, loose sands or soft clays are encountered at the proposed founding level, the excavation should be extended into underlying competent materials. Alternatively, any materials deemed unsuitable for founding should be removed and replaced lean mix concrete.
- 8.2.7 We have not been provided with a tree survey. Alternative founding options such as piled foundations may potentially need to be considered in areas of clay based soils where foundations need to extend beyond 2.5m due to tree influence. In such circumstances, it is recommended that allowances are made for steel tube or CFA piles. Additional site investigations (combined dynamic sampling / rotary cored boreholes) will be required to provide the geotechnical data for pile design. In areas where sandstone strata underlies the clay based soils it may be preferable to extend the trench fill foundation though to the sandstone.
- 8.2.8 Buried concrete should conform to Design Sulphate Class DS-1 and ACEC Class AC-1 of Special Digest 1 (3rd Edition, BRE, 2005).

8.3 Floor Slabs

- 8.3.1 Suspended / beam and block floor slabs will be required in localised areas due to tree influence, where plots are being raised or in areas of made ground (if encountered). Ground bearing floor slabs are likely to be appropriate elsewhere at the site.

8.4 Ground Contamination

- 8.4.1 The risk assessment included in Section 6 of this report identified that the levels of ground contamination in all of the soil samples tested are within acceptable limits for the proposed residential development. The topsoil (and subsoil) is considered suitable for re-use as part of the proposed development.
- 8.4.2 In the unlikely event that contamination is suspected during site enabling / construction works, procedures should be identified for dealing with unforeseen contamination. Specifically, works in the affected area(s) should cease and arrangements made for the suspected contamination to be inspected by a suitably qualified environmental specialist, followed by sampling and testing as appropriate. If these works identify the requirement for remediation, proposals should be communicated to the Local Planning Authority prior to implementation.

8.5 Ground Gas

- 8.5.1 There is a general absence of potential ground gas sources (i.e. made ground, recorded landfill sites, organic materials etc). On this basis, gas protection measures are not generally considered necessary for the site.
- 8.5.2 As discussed in Section 3.6, radon gas protection measures are not required.
- 8.5.3 It is recommended that the report is provided to the Local Authority at the earliest opportunity to confirm their requirements.

8.6 Groundwater / Stability

- 8.6.1 Groundwater was encountered in a single trial at 3.0m within sandstone of the Edwalton Member during the ground investigation; all other trial pits were recorded to be dry. It is considered localised seepages should be controllable by sump pumping.
- 8.6.2 The trial pits generally remain stable. Shallow excavations are unlikely to require support in the short term.

8.8 Soakaway Potential

- 8.8.1 The ground investigation revealed predominantly fine soils grading to interbedded mudstone and sandstone. The fine soils are generally considered to be of very low permeability and not suitable for soakaway drainage. The interbedded mudstone and sandstone present at a depth of 2.0m, is considered unlikely to be sufficiently permeable for soakaway drainage due to the preponderance of weathered mudstone. Groundwater was encountered at 3.0m at one location within the sandstone (although could be higher during / after periods of wet weather). Based on the foregoing these materials are not considered suitable for soakaway drainage.

8.9 Hard Strata

- 8.9.1 Bands of extremely weak sandstone are present at depths between 0.7m and 2.0m and were fully penetrated using a JCB 3CX. Hard strata comprising interbedded mudstone and sandstone are encountered between 1.8m and 3.3m at the base of the trial pits. Trial pits designated TP06 to TP08 were terminated between 1.9m and 2.5m on very weak sandstone. The JCB 3CX typically progressed through the thin bands of mudstone and sandstone with only two trial pits (TP01 and TP07) terminated due to limited progression (bucket scraping on the base).
- 8.9.2 It is considered the uppermost 2.0m of soils beneath the site should generally be achievable with similar plant to a JCB 3CX or larger. Should there be a requirement to excavate deeper than 2m then specialist plant may be required to achieve the target depth.

8.10 Recommendations for Further Investigation

- 8.10.1 Based on the information provided in this report the following outstanding issues have been identified which would benefit from further works:
- Foundation zoning plan and accompanying tree survey to determine if any plots will be affected by tree influence;
 - Possible requirement for deeper boreholes should a piled foundation solution be required.