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PROPOSED RESIDENTIAL DEVELOPMENT
LAND AT CHAPEL DROVE
HOLBEACH DROVE
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GEOENVIRONMENTAL GROUND INVESTIGATION REPORT – PHASE 2

Report Ref.: 0916/2

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PROPOSED RESIDENTIAL DEVELOPMENT

LAND AT CHAPEL DROVE ~ HOLBEACH DROVE

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1. INTRODUCTION.

1.1 General.

This report describes the findings of a geoenvironmental ground investigation undertaken by Goldfinch Environmental Limited, on the instruction of R K Wilson Ltd (the Client), via the offices of G R Merchant Ltd at a site off Chapel Drove and Holbeach Drove, Spalding, Lincs..

The site has been proposed for residential development as shown in Figure 2 towards the back of this report.

In accordance with the planning system the scope of work described in this report was the result of a consultation with the offices of South Holland District Council Environmental Health.

A site location plan as Figure 1, and a proposed layout plan (Figure 2), have been included towards the back of this report to assist the reader.

1.2 Additional Information.

This Phase 2 investigation report follows preparation and issue of a Phase 1 Desk Study report prepared by a Third Party reference Delta Simons Project No: 19-1448.01 Issue Date July 2022. This Phase 2 report prepared by Goldfinch Environmental Ltd includes pertinent information from the Desk Study in order to "*..link to the conceptual ground model*" [our italics.] which is updated following the results of the Phase 2 investigation.

It is recommended that the referred Phase 1 Report is read in conjunction with this Phase 2 report.

1.2.1 Author Note

The Reader should note that there are two aspects to this Phase 2 investigation comprising completion of the Phase 2, as recommended by the Third Party Desk Study, and characterisation [by chemical laboratory testing] of a large stockpile of soil located at

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the back of the site which has been proposed for reuse in soft landscaped and private domestic garden areas. The soil samples collected from the boreholes and stockpile are prefixed 'WS' and 'STK' accordingly.

The referred stockpile of soil is 'site-won' as a result of foundation works and formation of utilities/services corridors across the site. Site topographic levels are currently lower than proposed for the completed development therefore in the interest of sustainability it was considered that these stockpiled soils may be used for reinstatement where suitable, of the site levels subject to their 'geoenvironmental' quality and subsequent approval of the Regulator [SHDC Planning.].

1.3 Regulatory Position & Consultation

It was understood that a Third Party Phase 1 Desk Study had been submitted to the Regulator [South Holland District Council, SHDC] in accordance with the planning regime but the recommendations regarding 'further assessment/investigation' therein had not been fulfilled therefore a 'stop' notice had been placed on the development until such time as this further work was carried out and reported to the Regulator. This [Phase 2] report provides a description of the fieldwork, chemical laboratory testing and an updated conceptual model and risk assessment based upon the outcome of the investigation the scope of which had been agreed with the Regulator prior to commencement of the work

On conclusion of the review of the Third Party reports a proposed Phase 2 strategy was submitted to the Regulator, which was subsequently approved by their office and executed as described in the following sections of this report.

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2. LIMITATIONS.

This report is for the sole reliance and use of the Client. Any Third Party coming into possession of this report relies on it at their risk, unless written permission is expressly sought from, and provided by, Goldfinch Environmental Limited. The author owes them no duty of care and skill. Goldfinch Environmental Ltd accepts no responsibility or liability for the consequences of this document being used for purposes other than that for which it was commissioned and the assessments provided herein should not be relied on as a legal opinion.

The findings and opinions expressed are relevant to the time of the site visit and information review and should not be relied upon to represent conditions at substantially later dates. The assessments and opinions given in this report are based upon information available at the time of the report. Where additional information comes available which may affect or identify a need to review our conclusions or assessments we request the opportunity (and reserve the right), to review the information and where warranted, modify our assessment / opinion in part or wholly, accordingly.

The purpose of this desk study report was to determine the historical use of the site and adjacent areas from searches of Public Registers and a review of available historical maps and included a site reconnaissance (‘walkover’) survey together with brief internet searches. The outcome of these activities is described below and this information was used to construct a conceptual model for the site from which a risk assessment was completed in the context of the proposed residential development of the site.

The risk assessment was based on the source-pathway-receptor framework, with respect to the geoenvironmental condition of the site in the context of various sensitive receptors. Goldfinch Environmental Ltd have based this desk study upon the sources given in this report, and believes them to be reliable but cannot and does not guarantee the authenticity or reliability of the data it has relied upon.

This desk study does not include any geotechnical considerations pertaining to the site as these were outside the agreed brief.

The recommendations given in this report are based on guidance and best practice in place at the time of issue of the report, the information available at the time of the investigation, the nature of the indicated proposed development and associated end user behaviour patterns. Should any of the foregoing change at any time, then this report should be reviewed in the context of proposed changes.

The absence of indicators in search data, or from on site observations does not rule out their presence in other parts of the site. This desk study report has been based on information supplied in the ‘GroundSure’ report and its component parts included at Appendix 1 towards the back of this report, discussions with the Client and in-house searches.

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3. LEGISLATIVE & REGULATORY SETTING.

The Environmental Protection Act of 1990 created the framework for the identification and remediation of contaminated land. The Act defines “contaminated land” as any land, which appears by the Local Authority to be “in such a condition, by reason of substances, in, on, or under the land that significant harm is being caused or there is significant possibility of such harm being caused, or, pollution of Controlled Waters is being, or is likely to be, caused”.

Land potentially affected by ‘contamination’ is a material consideration for planning purposes together with its relationship with ‘regulatory intervention’ (Part IIa), and ‘voluntary’ investigation (which includes redevelopment of sites which may be affected by contamination). The Model Procedures (CLR-11, Environment Agency 2004), provide a generic framework indicating key technical activities applicable in each of these contexts.

The management of land contamination broadly comprises three components that are identified as ‘Risk assessment’, ‘Options appraisal’ and ‘Implementation’. These, in turn, determine if any *un*acceptable risks exist, ascertain the most appropriate remediation strategy for the site and, finally, demonstrate that the strategy will be effective.

In accordance with this and other current guidance, where a ‘land quality’ risk assessment is required each ‘Relevant Pollutant Linkage’ (RPL, formerly referred to as “source-pathway-receptor” framework), is separately identified and a level of risk attached. This is documented in the form of a ‘Conceptual Model’.

The outcome of the assessment of established, plausible relevant pollutant linkages is used to determine qualitatively the need for further investigation, or remediation with ensuing mitigation of the determined unacceptable risk. (In accordance with the Model Procedures and Regulatory preference, detailed remedial measures should be provided in a separate phase).

The risk assessment takes account of the local environment, end user behaviour patterns, and the nature of the development in relation to proven ‘unacceptable’ risk. This is the approach advocated by current guidance (CLR-11, CIRIA C665, BS8485, BS8576 and BS10175 etc), and therefore has been adopted in the assessment of this site.

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4. SITE LOCATION AND DESCRIPTION.

4.1 Introduction

At the time of the fieldwork and subsequent ground gas monitoring visits the site comprising a sensibly level plot of land and showed early stages of construction of the proposed dwellings i.e. construction had reached the stage where floors had been constructed. The floor construction detail comprised ‘block and beam’ and below this the presence of ‘air bricks’ was noted, these had been installed around the base of the dwellings to provide cross-flow ventilation of the subfloor void to minimise the potential of the build up of ground gases where present.

All other areas were down to a cover of exposed soils except for a gravelled area, which approximated the access route into the site.

During the course of the fieldwork which including the monitoring visits extended over a period of approximately three months, visual inspection of exposed soils revealed an absence of staining or unusual discolouration. At various times puddles of water from recent rain were present at the site and visual inspection of the surfaces revealed an absence of diffraction patterns the presence of which can indicate ‘contamination’.

It was understood from the Client that the topographic levels at the site were approximately 300-350mm lower than the final proposed levels.

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5. PRELIMINARY QUALITATIVE RISK ASSESSMENT [Reproduced from the Third Party Desk Study].

5.1 Introduction.

There are three factors that are taken into account whilst undertaking a qualitative risk assessment. These have been described in Section 3 of this document. At the time of this report, the site had been proposed for residential development.

5.2 Third~Party Conceptual Model.

The Conceptual Model from the Third Party Desk Study has been included below to assist the reader and for the purposes of clarity. Following completion of the fieldwork and outcome of the chemical laboratory testing and [quantitative] ground gas assessment this has been updated in Section 8 of this report.

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Contaminant Linkage Assessment					
Source(s)	**Pathway(s)**	**Receptor(s)**	**Risk**	**Comments**	**Requires Investigation**
Potentially contaminated soils and/or groundwater located beneath the Site.	Direct contact/ ingestion and inhalation of dust and vapours.	Site users.	Low Risk	Limited potential sources of contamination have been identified at the Site associated with the Sites former agricultural use and storage. A limited environmental investigation is recommended at the time of any geotechnical assessment to advise on the soil quality beneath the Site and the risk to Human Health and Controlled Waters. Although potential ACMs were observed during the first site walkover in September 2019 within sheet roofing and an on-Site stockpile, they were not directly observed during the second site walkover in July 2022 following building demolition and site clearance. However, the potential for potential ACMs and asbestos fibres to remain within the disturbed soils at Site cannot be discounted and investigation will be required to assess this. A clean layer of certified suitable for use topsoil will be required in landscaped areas.	Yes
	Direct contact, ingestion and inhalation of dust and vapours.	Maintenance workers during any future sub-surface works at the Site.	Low Risk	Site workers may become exposed to localised contaminated soils and shallow groundwater during intrusive groundworks undertaken at the Site. Safe working practices should be undertaken and appropriate Personal Protective Equipment (PPE) should be used that will reduce the risk to low. Intrusive investigation will inform potential risks in new development areas. A discovery strategy should be in place during the redevelopment for ground workers to act upon should suspected contamination be identified.	Yes
	Leaching of contaminants and vertical migration.	Groundwater beneath the Site.	Low Risk	Significant potential sources of contamination have not been identified associated with the current use of the Site, and whilst there remains the potential for localised contamination associated with the historical use of the Site, the risk to	Yes

Contaminant Linkage Assessment					
Source(s)	**Pathway(s)**	**Receptor(s)**	**Risk**	**Comments**	**Requires Investigation**
				underlying groundwater is considered to be low in the context of the Site setting and absence of sensitive surface water receptors. Intrusive investigation will be required to support planning for the new development area(s).	
	Permeation of hydrocarbons through plastic pipe work.	Water supply pipes.	Low Risk	It is considered prudent to undertake hydrocarbon testing of the shallow soils at the time of any environmental investigation to provide recommendations for the upgrading of any potable service pipes.	Yes
Ground gas.	Vertical and lateral migration of ground gases.	Site users & the buildings on-Site.	Low Risk	Limited sources of ground gas have been identified at the Site and in the surrounding area and are limited to Made Ground and Tidal Flat Deposits. As such, the risk to future Site users is considered low. Ground gas monitoring should be undertaken as part of ground investigation works to address the characteristic situation of the Site.	Yes

6. ENVIRONMENTAL SITE INVESTIGATION

6.1 Fieldwork.

Initially ground conditions were determined by advancing nine number exploratory locations [Ref WS1-WS9 inclusive] by percussive methods to depths of between approximately 1.00 – 3.00m. This included the installation of three wells [WS1–WS3 inclusive] to allow the collection of ground gas monitoring data. A summary of the ground gas monitoring data has been included in Appendix 3 towards the back of this report.

At the time of the fieldwork a stockpile of soil extended across the northern boundary of the site. It was understood that this was 'site won' as a result of a shallow site strip to establish a construction level and the arisings from foundation and drainage excavations. Discussions with the Client revealed that the reuse of this material on site was being considered. On that basis sampling for chemical laboratory testing of this stockpile was included in the fieldwork to assess its suitability for retention and reuse in the proposed development. For the purposes of clarity the soil samples from the stockpile were annotated 'STK A-D' inclusive.

The exploratory locations, (referenced WS1-9 and 'STK A' – 'STK D' inclusive), are shown on a plan of the site (not to scale), in Figure 2 towards the back of this report. The accompanying Exploratory Location Records (Logs) describing the soils encountered during the fieldwork have been included in Appendix 1 towards the back of this report.

Exploratory locations had been positioned having taken account of specific potential contamination sources, access, obstructions and defined/possible service/utility locations together with appropriate acknowledgement of the proposed layout for the development together with proposed garden and soft landscaping areas, as agreed with the Regulator. This is reflected in any differences shown in Figure 2 and the initial [strategy proposal] correspondence submitted to the Regulator prior to commencement of the fieldwork.

Soil samples (Ref WS1-9 and STK A – STK D inclusive) were taken across a variety of depths within the soil profile from the boreholes and the stockpile for chemical laboratory testing with a view to assessing their suitability for retention [either under hard cover or in landscaped and garden areas] at the site.

Site operations were carried out generally in accordance with BS 5930, "Code of Practice for Site Investigation", LCRM 2020 and BS 10175:2011 as required by the Regulator and 'best practice'.

Soil samples for inorganic analyses were placed in appropriate containers as advised by the laboratory depending on the suite of determinants required but typically included plastic tubs which sealed upon closure, 250ml amber glass jars with PTFE-lined screw-on tops or 60ml screw top jars or glass vials.

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Where appropriate, samples were placed in cool-boxes, pre-cooled to 4^{o}C ±2^{o}C, for delivery to the chemical test laboratory.

6.2 Laboratory Analyses.

Upon completion of the fieldwork the soil samples were despatched, under chain of custody, to a UKAS and MCERTS accredited analytical laboratory for analysis.

The analytical schedule for the soil samples (variously) comprised a broad suite of determinants which included a metals suite, pH, SOM, Speciated PAHs and asbestos as agreed with the Regulator. Additionally based upon site usage TOC and to a lesser extent TPH were added to the testing schedule.

The Chemical Laboratory Test Report(s) containing the factual test results are included in Appendix 2 towards the back of this report.

6.3 Groundwater Observations During Fieldwork.

Groundwater was not encountered as a ‘strike’ during the fieldwork but arising soils were ‘damp/wet’ as recorded on the exploratory location records provided in Appendix 1 towards the back of this report.

6.4 Proven Ground Conditions.

6.4.1 Overview.

The soil profile at the exploratory locations and in the stockpile was consistent within, and between, the exploratory locations and were generally described as dark brown slightly silty Clay with occasional subordinate gravel fractions.

There was no apparent evidence in the exposed soils of anthropogenic inclusions except at location WS1 where occasional fragments of [inert] comminuted brick were noted at very shallow depth.

Groundwater [as a definite ‘strike’] was not encountered in any of the exploratory borehole locations, although arising soils could be described as ‘wet’.

6.4.2 Made Ground

Made Groud was not encountered at any of the exploratory locations with the exception of occasional fine to medium gravel sized fragments of comminuted brick in WS1.

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6.4.3 Sand and Clay

This horizon was encountered in all the borehole locations from ground level and was generally described as dark brown slightly gravelly slightly silty Clay over orange brown slightly silty clayey Sand.

The base of this horizon was beyond the target depth of the investigation.

6.5 Evidence of Potential Contamination.

There were no indicators, olfactory or visual, of potential contamination in the arising soils at any of the exploratory locations. While occasional fragments of commminuted red brick were noted at very shallow depth in WS1 this material is considerd to be ‘inert’ and therefore not a plausible source of potential contamination.

6.6 Groundwater and Ground Gas Monitoring.

6.6.1 Groundwater

At the time of each of the ground gas and groundwater monitoring visits restimng water levels were below the target depth of the monitoring wells although a signal from the dipmeter suggested that the soils at the base of the wells was ‘wet’.

6.6.2 Ground Gas

The ground gas monitoring visits were carried out during 18 and 31 October, 15 and 29 November and 13 and 27 December 2023, respectively.

At the time of each of the six visits the measured concentrations of oxygen, carbon dioxide and methane were recorded together with associated parameters which included: depth to groundwater, flow, atmospheric oxygen and barometric pressure. This information has been tabulated and summarised in Appendix 3 of this report.

The results of the ground gas and groundwater monitoring program are discussed in Section 7.6 of this report.

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7. DISCUSSION OF CHEMICAL LABORATORY TEST RESULTS & GROUND GAS MONITORING RESULTS

7.1 Overview.

This section of the report provides commentary on the interpretation of the results of the chemical laboratory testing of the nine soil samples obtained from the site. The outcome of the review was to be carried forward into the [updated] Conceptual Model and Risk Assessment for the site which is included in Section 8 of this report.

The site has been proposed for residential development possibly with private gardens as described in Section 1 of this report and as shown in Figure 2 towards the back of this report. For the purpose of the assessment of the chemical laboratory test results [for the soil samples were compared to the LQM/CIEH 'S4UL' values for 'residential with home-grown produce' were employed as required by the Regulator with an organic matter content of **2.5**% (based upon the results of the chemical laboratory testing) taking the precautionary approach as required by the Regulator. [The reader should note that in the absence of an 'LQM/CIEH/S4UL' for lead the 'C4SL' value of 200mg kg^{-1} was employed.]

7.2 Land Contamination ~ Borehole Soil Samples.

7.2.1 Inorganic Determinants.

7.2.1.i Metals Suite

Nine soil samples from the boreholes were tested for a suite of metals which included Arsenic, Lead, Copper, Nickel, Chromium, Zinc, Cadmium, Selenium and Mercury.

When compared to current guidance values for human health assessment ['residential land use wth home-grown produce'] all of the tested soil samples *were below* their respective guidance values.

7.2.1.ii Asbestos

Nine soil samples were analysed for this determinant. One soil sample, WS8 @ 0.10-0.15m returned the result '*Chrysotile: Loose Fibres Detected*'.

7.2.2 Organic Determinants.

Nine soil samples were analysed for speciated polycyclic aromatic hydrocarbons (PAHs), a suite of sixteen species sometimes referred to as 'congeners'. The sixteen

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'congeners of concern' are discussed individually in Sections 7.2.2.i-xvi inclusive of this report.

7.2.2.i Napthalene.

Nine soil samples were analysed for this determinant. None of the samples exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 5.6mg kg^{-1}.

7.2.2.ii. Acenapthylene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 420mg kg^{-1}.

7.2.2.iii. Acenapthene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 510mg kg^{-1}.

7.2.2.iv. Fluorene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 400mg kg^{-1}.

7.2.2.v. Phenanthrene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 220mg kg^{-1}.

7.2.2.vi. Anthracene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 5400mg kg^{-1}.

7.2.2.vii. Fluoranthene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 560mg kg^{-1}.

7.2.2.viii. Pyrene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 1200mg kg^{-1}.

7.2.2.ix. Benzo[a]anthracene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 11mg kg^{-1}.

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7.2.2.x. Chrysene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 22mg kg^{-1}.

7.2.2.xi. Benzo[b]fluoranthene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 3.3mg kg^{-1}.

7.2.2.xii. Benzo[k]fluoranthene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 93mg kg^{-1}.

7.2.2.xiii. Benzo[a]pyrene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 2.7mg kg^{-1}.

7.2.2.xiv. Indeno(1,2,3-c,d)Pyrene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 36mg kg^{-1}.

7.2.2.xv. Dibenz(a,h)Anthracene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 0.28mg kg^{-1}.

7.2.2.xvi. Benzo[g,h,i]perylene.

Nine soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 340mg kg^{-1}.

7.3 Total Organic Carbon [TOC]

Nine soil samples were analysed for this determinant. The measured values varied between a minimum of 0.6 and a maximum of 2.3%. The arithmetic mean was calculated as 1.44%. These are considered to be 'Low' values.

7.4 Stockpile Soil Samples

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7.4.1. Inorganic Determinants.

7.4.1.i Metals Suite

Four soil samples were tested for a suite of metals which included Arsenic, Lead, Copper, Nickel, Chromium, Zinc, Cadmium, Selenium and Mercury.

When compared to current guidance values for human health assessment ['residential land use wth home-grown produce'] all of the tested soil samples *were below* their respective guidance values.

7.4.1.ii Asbestos

Four soil samples were analysed for this determinant. Asbestos was not detected in any of the four samples.

7.4.2. Organic Determinants.

Four soil samples were analysed for speciated polycyclic aromatic hydrocarbons (PAHs), a suite of sixteen species sometimes referred to as 'congeners'. The sixteen 'congeners of concern' are discussed individually in Sections 7.2.2.i-xvi inclusive of this report.

7.4.2.i. Napthalene.

Four soil samples were analysed for this determinant. None of the samples exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 5.6mg kg^{-1}.

7.4.2.ii. Acenapthylene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 420mg kg^{-1}.

7.4.2.iii. Acenapthene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 510mg kg^{-1}.

7.4.2.iv. Fluorene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 400mg kg^{-1}.

7.4.2.v. Phenanthrene.

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Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 220mg kg^{-1}.

7.4.2.vi. Anthracene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 5400mg kg^{-1}.

7.4.2.vii. Fluoranthene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 560mg kg^{-1}.

7.4.2.viii. Pyrene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 1200mg kg^{-1}.

7.4.2.ix. Benzo[a]anthracene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 11mg kg^{-1}.

7.4.2.x. Chrysene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 22mg kg^{-1}.

7.4.2.xi. Benzo[b]fluoranthene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 2.3mg kg^{-1}.

7.4.2.xii. Benzo[k]fluoranthene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 93mg kg^{-1}.

7.4.2.xiii. Benzo[a]pyrene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 2.7mg kg^{-1}.

7.4.2.xiv. Indeno(1,2,3-c,d)Pyrene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 36mg kg^{-1}.

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7.4.2.xv. Dibenz(a,h)Anthracene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 0.28mg kg^{-1}.

7.4.2.xvi. Benzo[g,h,i]perylene.

Four soil samples were analysed for this determinant. None of these exceeded the LQM-CIEH S4UL 'residential with home-grown produce' value of 340mg kg^{-1}.

7.5 Asbestos

Four soil samples were analysed for this determinant. The results showed that asbestos *was not detected* in any of the samples.

7.6 DISCUSSION OF THE RESULTS OF THE GROUND GAS MONITORING PROGRAM.

7.6.1. Overview.

This section of the report provides commentary on a review of the results of the ground gas monitoring data collected from the site. The outcome of the review is carried forward into a Conceptual Model and Risk Assessment for the site which is included in Section 8 of this report.

The site has been proposed for residential development as can be seen in Figure 2 towards the back of this report.

7.6.2. Discussion of the Ground Gas Monitoring Results.

7.6.2.1 Overview.

The proposed development is residential and anticipated to fall under "*CIRIA C665 Situation B – Low rise housing with a ventilated subfloor void (min 150mm)*".

Three ground gas monitoring wells (WS1, WS2 and WS3) were installed across the site as shown in Figure 2 towards the back of this report. These were positioned to take account of site access, services/utilities corridors and the proposed layout for the site.

The ground gas monitoring well locations are shown with red annotation on Figure 2 towards the back of this report.

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After allowing the wells to 'condition' for a minimum of 72 hours as recommended, six visits to site were made at approximately 2-week intervals [including through the seasonal holiday] to collect groundwater and ground gas concentrations in each of the wells. A full summary of the collected data is included in Appendix 3 towards the back of this report.

The referred site visits took place on 18 October 2023, 9 November 2023, 14 November 2023, 28 November 2023, 13 December 2023 and 27 December 2023. During these visits barometric pressure varied between 994 and 1007mb with these measurements being recorded during both falling and rising barometric pressure regimes. These observations are recorded on the summary sheets in Appendix 3 towards the back of this report.

During the fourth visit, which followed a period of heavy rain no data was collected from Borehole WS3 towards the rear of the site as the area was 'under water'. Prior to the fifth visit it was posible to create a 'sump' to drain the area and thus allow continuation [serviceability of the installation] of data collection.

CIRIA Report C665 recommends a risk based approach designed to allow identification of gas protection measures for low rise housing by comparing gas emission rates to generic "traffic light" scenarios. These include 'typical maximum concentrations' provided for initial screening purposes and risk based screening values (GSVs) for consideration in situations where the typical maximum concentrations are exceeded.

The method recommends calculating GSVs for both methane and carbon dioxide [where detected in excess of the ground gas monitor detection limit of 0.1% respectively] and adoption of the 'worst case' to establish appropriate protection levels.

At this point the reader should note that recorded concentrations of methane were at, or below the detection limit of the instrument of 0.1% v/v, on all of the six monitoring visits in the three boreholes. On that basis it is not necessary to derive a GSV for this ground gas.

7.6.3 Barometric Pressure Regime During the Monitoring Period.

In accordance with recommended practice data collection included measurements taken during conditions of "falling atmospheric pressure" as well as at least one dataset from a barometric pressure close to, or less than, 1000mb. During the monitoring period the lowest barometric pressure reading was 994mb noted at the time of the second monitoring visit during 9 November 2023.

As a general comment, two of the monitoring visits took place at barometric pressure concentrations of less than 1000mb suggesting that some of the data had been obtained over two visits which were considered 'worst case' conditions.

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7.6.4 Flow

On each of the three monitoring visits measured flow rates were at, or below the limit of detection of the instrument (<0.1l hr^{-1}).

7.6.5 Methane

As referred above, methane was not detected in any of the three borehole installations on any of the six monitoring visits.

7.6.6 Carbon Dioxide

A review of the dataset showed that carbon dioxide concentrations were highest and consequently oxygen concentrations were lowest in borehole WS3 located in the north [rear] of the site compared to WS1 and WS2 in the south [front] of the site. The 'Characteristic Situation' ['CS] has been determined from the adopted GSV and the ranges given in Table 2 in BS8485 guidance.

A 'peak' concentration of carbon dioxide of 5.9% v/v was recorded in borehole WS3 at a ['low'] baromentric pressure of 995mb. This value has been used as 'worst case' in derivation of the GSV. [An arithmetic mean of approximately 4% v/v carbon dioxide was calculated from the dataset.].

This value of 5.9%, gives a gas screening value (GSV, from dividing gas concentration % by 100 then multiplying by flow rate of 0.1 l hr^{-1}, the detection limit of the instrument for this parameter) of 5.9/100 x 0.1 = **0.0059 l hr^{-1}**.

This is associated with a [BS8485:2015+A1:2019] 'hazard potential' of 'low'[1] and places the site into a Characteristic Situation 2 due to carbon dioxide being slightly above 5% [*on the first visit only*]. [CS1 indicates less than 5% carbon dioxide]. At this point the Reader should note that 'flow' was not detected above the dettection liumit of the instrument of 0.1l hr-1.

However, in this instance adopting the precautionary approach, it is recommended that Characteristic Situation 2 (CS2) measures are adopted as a minimum.

The recommendations in the following sections of this report regarding ground gas are based upon this Characteristic Situation 2 assessment.

7.6.7 Oxygen

[2] Current & End User
[3] UK Water Industry Research. GUIDANCE FOR THE SELECTION OF WATER SUPPLY PIPES TO BE USED IN BROWNFIELD SITES. *Report Ref. No. 10/WM/03/21*. 2010.

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Oxygen levels were slightly depleted in proportion to the measured concentrations of carbon dioxide as would be reasonably expected, and then recovered slightly during the monitoring as other gas concentrations fell.

7.6.8 Total Organic Carbon

Nine soil samples were analysed for this determinant. The measured values varied between a minimum of 0.6 and a maximum of 2.3%. The arithmetic mean was calculated as 1.44%. These are considered to be 'Low' values thus indicating a 'Low' potential for ground gas generation.

7.7 Concluding Remarks to Section 7

7.7.1 Soils From Boreholes

Nine soil samples were analysed for a broad suite of determinants commonly employed in assessing the human health risk of soils in contaminated land assessments. None of the tested soil samples exceeded their respective guidance criteria except for one soil sample, [WS8 @ 0.10-0.15m] in which the '*Chrysotile: Loose Fibres Detected*' form of asbestos was detected.

7.7.2 Soils from Stockpile

Four soil samples were analysed for a broad suite of determinants commonly employed in assessing the risk to human health of soils present at any given site. None of the tested soil samples exceeded their respective guidance criteria

7.7.3 Ground Gas

The outcome of the ground gas assessment showed a maximum concentration of carbon dioxide of 5.9% v/v. This is slightly over the 'CS1' or 'Very Low' category and therefore on a precautionary basis [and in the absence of any recorded gas flow] it is recommended that that this is upgraded to CS2 i.e. 'Low' risk situation and that measures commensurate with this risk category are adopted as a minimum.

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8. UPDATED CONCEPTUAL MODEL & RISK ASSESSMENT

8.1. Overview.

In accordance with guidance current at the time of this report, there are three principal factors that are assessed whilst undertaking a qualitative risk assessment. These are described above in Section 3 in the context of 'Relevant Pollution Linkages' (RPL). At the time of this report, the site had been proposed for redevelopment to a residential land use therefore 'residential with home-grown produce' assessment criteria were used for the assessment of the laboratory testing results as described above and the following risk assessment.

8.1.1. Conceptual Model.

Sources (Proven)	Pathway	Target	Risk
Soil: **Borehole Soil Samples** The intrusive investigation has shown that all of the tested soil samples were below the 'residential with home-grown produce' S4UL guidance values as described above, with the exception of **WS8, D1, 0.10-0.15m [Chrysotile]**. **Stockpile Soil Samples** The chemcal laboratory testing has shown that all tested determinants did not exceed their respective guidelines for human health risk assessment suggesting these soils are suitable for reuse in domestic gardens and soft landscaped areas across the site.	❖ Dermal contact, ingestion and inhalation ❖ Wind erosion and atmospheric dispersion ❖ Leaching	• Present users • End users • Construction workers • General public	• Low • **Low-Med** • Low-Med • Neg
		• Adjacent properties • General public • Shallow groundwater • Services/construction materials • Plant life • Surface water	• Neg • Neg • Neg • Neg • Neg • Neg
Shallow groundwater: Groundwater was not encountered as a 'strike' in any of the exploratory locations. The measured concentrations of all soil-borne determinants were not considered to pose an 'unacceptable' risk to this environmental medium.	❖ Groundwater migration	• Adjacent properties • Deep groundwater • Services/construction materials • Plant life • Surface Water	• Neg • Neg • Neg • Neg • Neg-Low
	❖ Dermal contact, ingestion and inhalation	• Present users • End users • Construction workers • General public	• Neg • Neg • Neg • Neg

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Gas: There were no specific ground gas sources identified by the Third Party Desk Study within 250m of the site and a 'Low' risk was associated with the likelihood of the presence of soil/groundwater/ground gas contamination at the site however, a detailed ground gas assessment was recommended. At the time of the fieldwork there were no observable [plausible] sources of ground gas as a result of historical site use. Floor construction of the new dwellings includes a ventilated subfloor void. The TOC analyses carried out on soil samples from the site indicated a 'Low' potential for ground gas generation. The interpretation of the results of the full program of ground gas monitoring revealed the site was classed as a CS2 i.e. 'Low Risk'. Therefore it is recommended that on a precautionary basis that CS2 ground gas protection measures are incorporated into the buildings as a minimum.	❖ Direct inhalation ❖ Soil migration ❖ Services migration	• End users • Construction workers • Buildings	• **Low-Med** • Very Low • Low

Negligible Risk	Defined as the site should be considered suitable for present or future use and environmental setting. Contaminants unlikely to be present, which might have unacceptable impact on key targets.
Low Risk	Defined as the site should be considered suitable for present or future use and environmental setting. Contaminants may be present but unlikely to have unacceptable impact on key targets.
Medium Risk	Defined as the site may not be suitable for present or future use and environmental setting. Contaminants are probably present and might have unacceptable impact on key targets.
High Risk	Defined as the site is probably or certainly not suitable for present or future use and environmental setting. Contaminants probably or certainly present and likely to have an unacceptable impact on key targets.

8.2. Updated Risk Assessment.

8.2.1. Targets.

Potential targets/receptors, in the context of the risk assessment, where a plausible pathway can be proven, are discussed under separate subheadings as follows:-

8.2.2. Human Health (Site Users[2] & Construction Workers).

8.2.2.i Borehole Soils Samples

The results of the chemical laboratory testing showed that all the tested soil samples were below their respective guidance values except WS8, D1, 0.10-0.15m [Chrysotile asbestos].

In the context of the proposed end use for the site and the localised distribution, depth, measured concentration values and contaminant type:-

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A *Low-Medium* risk has been identified.

8.2.2.ii Stockpile Soil Samples

The results of the chemical laboratory testing showed that all the tested soil samples were below their respective guidance values for human health risk assessment.

In the context of the proposed end use for the site and the localised distribution, depth, measured concentration values and contaminant type:-

A *Negligible-Low* risk to human health has been identified with these soils, and the chemical laboratory testing has shown that these soilsg are suitable for use in domestic gardens and soft landscaped areas.

8.2.3. Construction Workers.

8.2.3.i Borehole Soil Samples

During the opening up and disturbance of ground at the referred locations, as part of demolition and construction works, construction staff, particularly groundworkers, are likely to be exposed locally to borehole WS8 ‘contaminated’ soils [i.e. those likely to contain determinants that exceed their respective guidance criteria, in this instance chrysotile asbestos] and soil dusts (e.g., when manually handling soil and working in excavations):-

Based on the localised distribution, depth, measured concentration and contaminant type:-

A *Low* risk has been identified.

8.2.3.ii Stockpile Soil Samples

The results of the chemical laboratory testing showed that all the tested soil samples were below their respective guidance values for human health risk assessment.

In the context of the proposed end use for the site and the localised distribution, depth, measured concentration values and contaminant type:-

A *Negligible-Low* risk to human health has been identified with this source.

8.2.4. Services and Construction Materials.

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8.2.4.1. Concrete.

Concentrations of determinants are not considered to present an 'unacceptable' risk to this Receptor.

A *Negligible* risk has been identified.

8.2.4.2. Potable Water Supplies.

UK Water Industry Research (UKWIR), provides guidance[3] on material selection to prevent water supply lines failing prematurely. The chosen parameters are based on the potential for:

(a) taste or odour impairment of potable waters by permeation of organic contaminants through polymer-based pipework;

(b) the structural or physical deterioration of pipework materials;

(c) the contamination of the interior surfaces pipework when undertaking maintenance;

(d) health and safety of workers when undertaking repairs.

Some of these parameters follow other existing guidance, which have either been withdrawn or updated including the WRAS guidance of October 2002 (e.g., ICRCL and BRE Special Digest 1).

The UKWIR report only cites organic determinants as contaminants of concern. The investigation has shown very localised instances of marginally elevated PAHs in soils. Therefore:~

A *Negligible* risk has been identified.

8.3. Landscaping & Planting.

No signs of stress or unusual staining in plant life was noted.

A *Negligible* risk to plantlife has been identified.

[3] UK Water Industry Research. GUIDANCE FOR THE SELECTION OF WATER SUPPLY PIPES TO BE USED IN BROWNFIELD SITES. *Report Ref. No. 10/WM/03/21*. 2010.

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8.4. Ground Gas.

Based on the results of the ground gas monitoring and the assessment given in this report a 'Low' risk (CS2) is associated with the the ground gas regime operating at the site and 'low-level' protection measures are recommended on a precautionary basis.

The Reader should note that flow levels were below the detection limts of the instrument of 0.1l hr^{-1} and measuredc TOC content in soils from the site were considered to be 'Low'.

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9. REMEDIATION RECOMMENDATIONS.

9.1. Land Contamination – Borehole Soil Samples.

The results of the chemical laboratory testing showed that all the tested soil samples were below their respective guidance values for human health risk assessment except for WS8, D1, 0.10-0.15m [Chrysotile asbestos]. This location appears to be coincident with an area of soft cover [private rear garden area to Plot 4],

This sample depth is approximately 0.4-0.45m depth relative to proposed final topographic levels therefore remedial treatment of the soils in this area will be required in order to reduce the current risk.

It is recommended that 300-350mm of soils are removed from this plot, and replaced with approximately 600-700mm of compliant soils such as those in the stockpile at the rear of the site to restore site levels. A permeable membrane should be installed at the reduced surface thus separating the residual soils land the replacement compliant soils. This is to act as a marker layer and top prevent soil mixing by [burrowing] animal activity.

In order to provide verification that this activity has been completed it will be necessary for the Client to collect the following information where applicable :~

1. Soil removal documentation - Waste Transfer Notes.

2. Soil import documentation - Delivery notes for imported soils where existing on-site source not used.

3. The Environmental Engineer will make the required visit(s) to site on completion of the works.

4. The depth of the imported clean soil cover system where required can be verified by placement of vertical sections of drainpipe once the residual level has been established and *prior to* commencement of the upfill/backfill operations. **This should allow the depth to the residual surface to be measured and the level to the reinstated surface [down the outside of the pipe section] the difference between these two measurements should be a minimum of 600mm including an allowance for any 'settlement'.** Two number locations within the rear garden of Plot 4 are suggested.

5. Photographic records should show the reduced levels and placement of any membranes employed as 'break' layers between existing and imported soils where this option is chosen.

6. The Reader should note that prospective import soils will need to be

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approved by the LPA *prior* to being brought to site. This usually takes the form of submission of correspondence including a chemical laboratory test report for the candidate soils and risk assessment which should demonstrate that unsuitable or 'contaminated' soils are not being imported into the site. This can either be provided in an Appendix towards the back of an RMS, or as 'stand alone' correspondence which should later be included in the Verification Report.

7. It is usual practice for the remedial works to take place post-construction as part of the landscaping scheme for the [any] development. This is to avoid any 'spoilage' by ongoing construction work at this or any other site.

8. The Verification Report should also contain an updated risk assessment based upon the post-remedial condition of the site.

On completion of this the associated human health risk from this source can be reduced from *Low-Medium* [at present] to *Negligible-Low*.

9.2 Ground Gas.

Based on the results of the ground gas monitoring and the assessment given in this report a 'Low' risk (CS2) is associated with the the ground gas regime operating at the site and 'low-level' protection measures are accordingly recommended.

Appropriate mitigation measures [from guidance] should be employed as follows:~

1. Suspended beam and block floor with ventilated sub-floor void.

   [Author Note: At the time of the fieldwork, construction was at the "out-of-the-ground" stage and it was confirmed that block and beam floor construction with ventilated sub-floor void had been completed as evidenced by exposed air bricks which provide the cross-flow ventilation of the referred void. No membrane had been installed at this stage.].

2. Installation of a gas-proof membrane:~

   2.i Often a 1200 gauge membrane would be used at this stage however, in this instance it is recommended that this is upgraded to a minimum of 2000 gauge [or better]. This will ensure enhanced protection over 'standard' and be more mechanically robust [i.e. tear-resistant] during the installation process.

   2.ii The membrane should be installed in accordance with the manufacturers instructions.

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2.iii All joints and 'penetrations' e.g. service entry points, to be sealed.

2.iv Joints to be overlapped by a minimum of 300mm and to be taped/sealed with recommended approved materials.

2.v Inspection for tears or rips in the membrane to be included in the validation process which at the Engineers choice can be supported by photographic images demonstrating absence of tears and other 'discontinuities'.

3. Verification: It is understood from the Client that SHDC require that gas protection measures are installed by one of the Contractors from their list of [SHDC-] approved Contractors. On that basis it is assumed by this Author that said installer[s] will also provide validation services culminating in submission of suitable records regarding installation of the ground gas protection measures for the approval of SHDC, and that this will be outside the current agreed briek between the Client and Goldfinch Envrionmental Ltd [GEL]. Variation to this should be communicated to GEL at the earliest opportunity to ensure the validation process can be complied with.

4. On-going monitoring at the site is not warranted.

On completion of this the associated human health risk from this source can be reduced from *Low-Medium* [at present] to *Negligible-Low*.

The proposals included in this Section of this report are subject to the approval of the Regulator.

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10. CONCLUSIONS.

This geoenvironmental ground investigation report prepared by Goldfinch Environmental Limited was undertaken on the instruction of R K Wilosn Ltd (the Client), via the offices of G R Merchant Ltd at a site off Chapel Drove and Holbeach Drove, Spalding, Lincs..

The results of the chemical laboratory testing have shown that all the tested soil samples were below their respective guidance values except for WS8, D1, 0.10-0.15m [Chrysotile form of asbestos].

The outcome of the ground gas assessment included in this Phase 2 investigation show that 'low-level' ground gas protection measures will be required to mitigate the current risk to human health.

Management of these instances have been discussed with recommendations in Section 9 of this report.

An *overall Low-Medium* risk is associated with the site subject to the recommendations in Section 9 and *the final paragraph in this report.* The Reader should note that upon acceptance of this report by SHDC and completion of the referred mitigation [remediation] including submission of Verification documentation to the satisfaction of SHDC this risk can be reasonably downgraded to '*Negligible-Low*' and application can be made for full discharge of the Condition relating to 'contaminated land'.

The reader should note that the opinions, recommendations and conclusions in this report are subject to the agreement of the Local Authority who are the final arbiters in these matters.

Site personnel, particularly groundworkers, should still follow sound health and safety welfare practices that will further mitigate this level of risk.

Should unanticipated contamination be suspected, or revealed during any groundworks, then the area should be temporarily isolated and further advice sought by a suitably independent qualified person and a management strategy for these occurrences should be submitted to the Local Authority for their approval prior to proceeding, as required by Regulatory Offices.

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