

**CONSULTING ENGINEERS**

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**PROPOSED RESIDENTIAL DEVELOPMENT  
ARTHURS LANE, HAMBLETON  
LANCASHIRE  
FOR  
WAINHOMES NW LIMITED**

**APRIL 2018**

**PHASE II GEO-ENVIRONMENTAL INVESTIGATION REPORT**

**18038/GEIR**

**ROBERT E FRY & ASSOCIATES LTD.**  
45, Bridgeman Terrace  
Wigan, WN1 1TT

Telephone: 01942 826020  
Fax: 01942 230816  
Email: [mail@refa.co.uk](mailto:mail@refa.co.uk)  
Company Registration No. 2436911



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### EXECUTIVE SUMMARY

<b>Site</b>	<i>The site is irregular in shape and extends to an area of 10.4 hectares. It is located to the east of Arthurs Lane approximately 500m east of the village centre of Hambleton.</i>
<b>NGR</b>	<i>337868 442771</i>
<b>Site History</b>	<i>A review of the historical maps shows that the site has remained in agricultural usage throughout its entire history although Crooklands Farm has now been demolished and removed.</i>
<b>Investigations</b>	<p><i>The investigations have extended to:-</i></p> <ul style="list-style-type: none"> <li><i>• Initial walk over survey</i></li> <li><i>• Intrusive investigations by trial pits</i></li> <li><i>• Chemical and geotechnical analysis of soil samples</i></li> <li><i>• Assessment of results</i></li> </ul>
<b>Ground Conditions</b>	<i>Topsoil has been identified across the majority of site varying in thickness between 0.2 - 0.4m. Made ground has been identified within positions TP01 – TP02 and proven to a maximum depth of 0.7m bgl. Underlying the topsoil and made ground is the presence of natural strata that comprises of firm to stiff clays over the whole site area and has been proven to a maximum depth of 2.9m bgl. No bedrock has been identified.</i>
<b>Groundwater</b>	<i>Groundwater ingress has been identified within positions TP07, TP14 and TP27 at depths between 1.5 – 2.4m bgl. These water strikes are considered to represent perched water within the natural strata. It should be noted that perched water in granular units may cause localised instability in excavations and the foundations. Instability was noted within position TP14 due to groundwater ingress and where excavations must stop if difficulties with groundwater are encountered and the foundations engineer must be consulted.</i>
<b>Environmental</b>	<i>Chemical testing has confirmed the topsoil material to be free of any potential contamination and it is suitable for re-use within a private residential garden environment. The made ground material is also suitable for retention.</i>
<b>Trees</b>	<i>The site contains numerous semi mature trees located around the site boundaries. The proposed development plan shows that existing trees will be retained. All trees within the site area and those lying outside the site but within influencing distance should be subject to an arboriculturist report. The clay soils within this site have a MEDIUM volume change potential as defined by the NHBC.</i>
<b>Foundations</b>	<i>The natural strata offer a safe bearing capacity in excess of 100kN/m<sup>2</sup> at a minimum depth of 0.9m below finished ground level. Shallow strip foundations will be suitable for the majority of the site. In those areas where tree root effects are of concern deep trench fill foundations may be required to depths up to 2.5m below ground level. Foundation depths should be designed in accordance with NHBC Handbook Chapter 4.2</i>
<b>Slabs</b>	<i>It is recommended that all properties within this site should be provided with a suspended ground floor construction. The floors may be of a precast concrete beam and block arrangement or of cast insitu reinforced concrete. In those areas where tree effects are important it may be preferable to adopted pc floors to allow sufficient air void below the floor in accordance with NHBC recommendations.</i>

*This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.*

## **PHASE II GEO-ENVIRONMENTAL INVESTIGATION WORKS**

### **ARTHURS LANE, HAMBLETON, LANCASHIRE.**

#### **1.0 INTRODUCTION**

##### **1.1 Instructions**

1.1.1 *We are instructed by Wainhomes NW Ltd., Kelburn Court, Daten Park, Birchwood, Warrington, WA3 6UT to undertake a program of intrusive geo-environmental investigations at a site situated east of their Arthurs Lane, Hambleton, Lancashire. This site has been the subject of a previous Phase I desk study prepared by Enzygo Environmental Consultants (report reference SHF.1132.039.GE.R.001.A) dated February 2016 on behalf of Gladman Developments. Reference should be made to the previous desk study report when considering this report.*

##### **1.2 Object**

1.2.1 *The object of these investigations were as follows:*

- *To enable sufficient information regarding ground conditions to be obtained from which risks to end users and the environment may be assessed;*
- *To utilise the information obtained from the investigations to provide recommendations for remediation measures where required;*
- *To determine the engineering properties of the soils present within the site to form a basis upon which foundation and general infrastructure recommendations and design may be based.*

##### **1.3 Scope**

1.3.1 *The investigations considered within this report have comprised of the following elements and are based upon the principles and recommendations presented in BS10175:2011 "The Investigation of Potentially Contaminated Sites".*

- *Review of previous reports;*
- *Undertake intrusive ground investigation works utilising trial pits;*
- *Determine the presence, nature and extent of any soil and groundwater contamination at the site;*
- *Determination of the engineering properties of the soils present within the site to form a basis upon which recommendations for foundations and infrastructure construction may be based;*
- *Assess the possible presence of toxic and explosive gases;*
- *Identify the potential requirements for any remedial actions where required.*

##### **1.4 Development Proposals**

1.4.1 *The current development proposals are shown upon the appended site layout drawing 17-084-0001-REV C. The development comprises of a total of one hundred and sixty five (165 No.) residential properties with associated car parking, road access, garden areas and public open space (POS). Existing ponds are to be retained as part of the development.*

1.4.2 It is acknowledged within this report that the redevelopment proposals will be subject to planning approval and it is possible that the proposals shown upon the preliminary sketch site layout may be amended as a result of local planning and commercial requirements.

## 1.5 Services

1.5.1 Service information has not been provided by the client however during the site walkover overhead electricity lines have been identified within the southern area of the site.

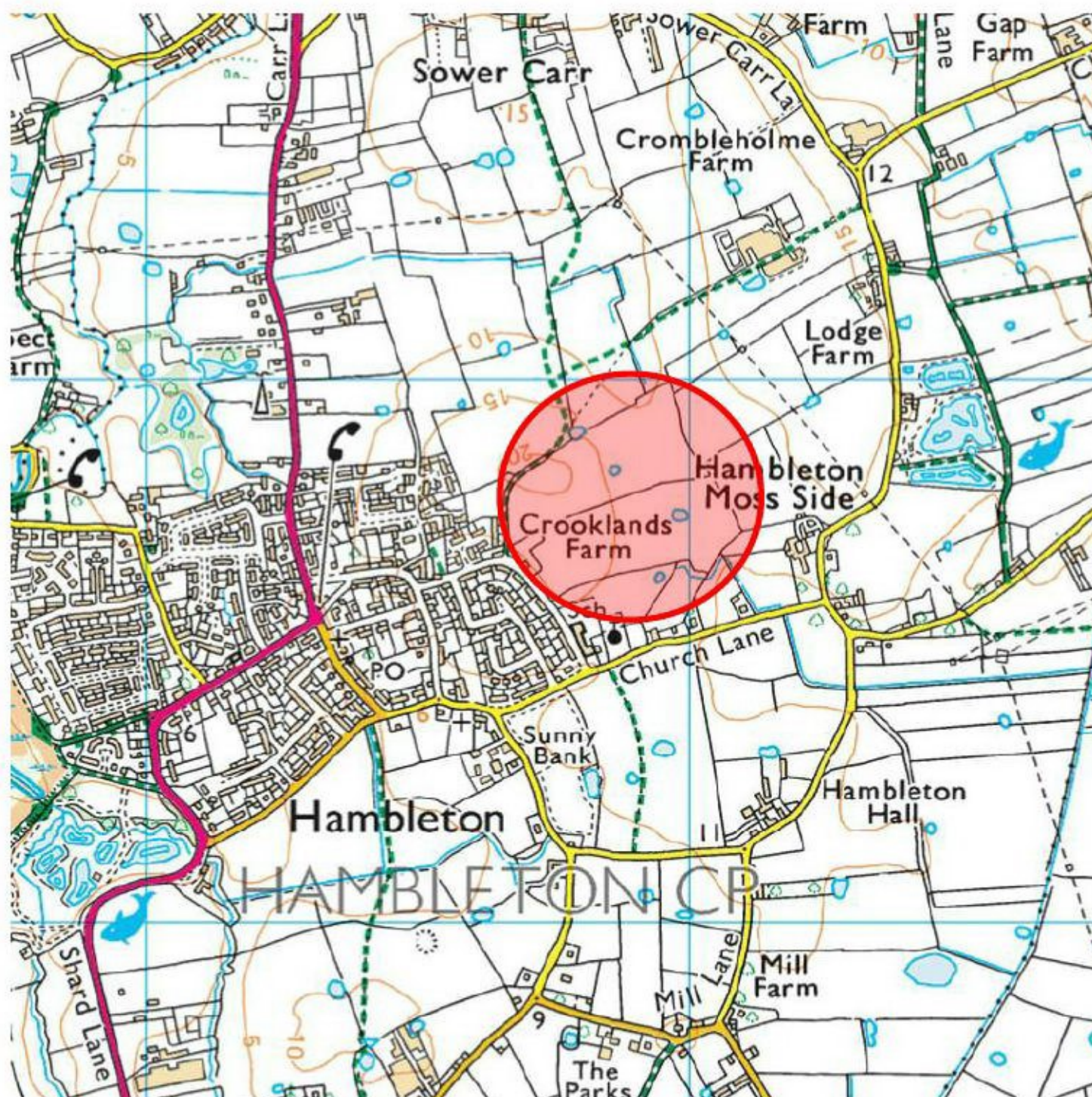
1.5.2 The excavation of trial pits within the site have been preceded by a utility search by a cable avoidance tool (CAT).

## 2.0 REVIEW OF PREVIOUS STUDIES

### 2.1 Site Location

2.1.1 The site is irregular in shape and is located on the eastern side of Arthurs Lane approximately 500m east of Hambleton village centre. The site extends to an area of approximately 10.4 hectares and the centre of the site is situated at approximate National Grid Reference SD 337868 442771. This location is shown in figure 1 below.

**Figure 1: Site Location**



## **2.2 Previous Phase I Summary**

2.2.1 This site has been the subject of a previous desk study prepared by Enzygo Environmental Consultants dated February 2016 (Report Ref: SHF.1132.039.GE.R.001.A). This study undertaken by Enzygo provided an environmental appraisal of the site and included the review of the environmental setting, review of propriety environmental database, review of historical plans and geological report. The report should be read in full however the main findings are presented below:

- The site walkover confirmed that the site comprises of two parcels of agricultural land, a yard area and two ponds;
- The site walkover has also identified overhead power lines located within the southern parcel of land that trend in a general east to west direction;
- A review of the historical maps has identified the former Crooklands Farm located adjacent to the western boundary with the remainder of the site being maintained as agricultural fields;
- The underlying geology is considered to comprise of Divensian Glacial Till deposits overlying Sidmouth Mudstone Formation. The superficial deposits are noted to be unproductive and the underlying bedrock aquifer is noted to be a secondary B;
- The desk study has not identified any significant sources of contamination on site or following a review of the history of the site;
- No viable sources of ground gases have been identified within close proximity to the site.

2.2.2 REFA recommended that intrusive investigations are required. The scope of works for the ground investigation should comprise the following:-

- Program of ground investigations to identify the strata sequence and assess engineering properties;
- Sampling of the existing strata for chemical and civil engineering laboratory test purposes;
- Program of chemical analysis upon representative samples of the strata to determine the suitability for reuse and within residential environment;
- Reinstatement;
- Preparation of factual and interpretative report.

## **3.0 PRELIMINARY CONCEPTUAL SITE MODEL**

### **3.1 Risk Assessment Methodology**

3.1.1 A review of the previous information has allowed a preliminary conceptual site model to be provided below. The conceptual site model is now shown in Table 2 below. This report adopts the methodology for risk evaluation presented in CIRIA report C552 'Contaminated Land Risk Assessment – A Guide to Good Practice', 2001. The method is qualitative and involves the classification of the following:



- The magnitude of the potential severity or consequence of the risk occurring;
- The magnitude of the likelihood or probability of the risk occurring.

3.1.2 Once the likelihood of an event occurring and its severity have been classified, a risk category can be assigned using Table 1.

		<b>Table 1: Comparison of Consequence against Probability</b>			
		<b>Consequence / Risk</b>			
		Severe	Medium	Mild	Minor
<b>Probability</b>	High Likelihood	Very High	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low Likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

3.1.3 In the context of regulatory definition of 'Contaminated Land' (as defined by the EPA 1990), 'very high' and 'high' risks would fall under the classification of 'Contaminated Land'. 'Moderate' risk could also potentially be classified as 'Contaminated Land' but any lower risk rating would not. Thus the following potential exposure pathways between potential and known contaminant sources based on information provided to date and receptors are tentatively identified in Table 2 overleaf.

**Table 2: Preliminary Conceptual Site Model**

Potential Source	Potential Receptor	Possible Pathway	Probability	Consequence	Risk	Mitigation / Investigation
Contaminated Soils	Site personnel during construction	Direct contact of soils Inhalation or ingestion of soil / dust	Lw	Md	Moderate / Low	Soil sampling during intrusive investigations. Laboratory analysis of samples
	Future site users	Direct contact of soils Inhalation or ingestion of soil / dust	Lw	Md	Moderate / Low	
	Surface water in the vicinity of the site	Leaching of contaminants through drainage system	Lw	Md	Moderate/Low	
	Ground water in aquifer	Leaching of contaminants to ground water	Ul	Md	Low	
	Future site users	Vapour migration from soils	Lw	Mri	Low	
	Proposed buildings and services	Direct contact with contaminated soils	Lw	Mi	Low	
	Plants in gardens and soft landscaping	Direct contact	Lw	Mi	Low	
Contaminated ground water	Site personnel during construction	Water entering excavations	Lw	Mi	Low	Sampling of ground water (where encountered)
	Future site Users	Retained surface water	Lw	Mi	Low	
Toxic and explosive gasses	Proposed buildings and occupiers	Ground gas migration into buildings	Lw	Md	Moderate / Low	Program of ground gas monitoring (if proved to be necessary)
Radon Gases	Proposed buildings and occupiers	Ground gas migration into buildings	Ul	Md	Low	No radon gas precautions required
Key: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely						

## 4.0 SITE WORKS

### 4.1 Walkover Survey

4.1.1 Prior to commencing any further intrusive ground investigations, a walkover survey of the site was undertaken to ensure that the site conditions were similar to those reported in the initial desk study by Enzygo. This walkover appraisal identified that the site remains in a similar condition to that of the previous desk study.

### 4.2 Intrusive Works

4.2.1 The ground conditions at this site have been investigated by the excavation of thirty nine (39 No.) trial pits supervised by a REFA engineer using a backhoe excavator. Trial pits were excavated to a maximum depth of 2.9m bgl.

4.2.2 During the excavation works representative samples of soils encountered have been obtained for laboratory analysis and testing. Insitu testing was also carried out during the excavations in the form of hand shear vane testing to determine the geotechnical properties of the cohesive materials present.

### 4.3 Locations

- 4.3.1 *The locations of the trial pits were chosen by this practice in conjunction with the desk study information and the service locations in an effort to identify the representative ground conditions present across the whole site area.*
- 4.3.2 *The locations of each of the trial pits are indicated upon the appended exploratory hole location plan 18038/03. These locations are shown in relation to site features present at the time of the investigation.*

### 4.4 Records

- 4.4.1 *During the investigations details of the strata types, water entries, ground conditions and levels have been maintained by a REFA engineer. This information has been collated into a series of trial pit records which are appended to this report for reference. During these investigations representative samples of the strata encountered have been retained for laboratory testing as required.*

### 4.5 Targeting

- 4.5.1 *The previous desk study information identified the former Crooklands Farm was located immediately adjacent to the site entrance off Arthurs Lane and therefore trial pits have been carried out within this area to identify any potential made ground deposits.*
- 4.5.2 *The trial pits were undertaken to identify the strata present over the whole of the proposed development area, though it is acknowledged that ground conditions may vary between trial pit locations.*
- 4.5.3 *The investigation locations have been spread over the whole area of the site in accordance with the recommendations laid down in BS10175: 2011 "Investigation of Potentially Contaminated Sites". The initial ground investigation strategy is detailed within table 3 below.*

<b>Table 3: Initial Ground Investigation Strategy</b>		
<b>Exploratory Hole No.</b>	<b>Target</b>	<b>Purpose</b>
TP4 – TP39	Generally over the site area.	<i>To determine the general nature of underlying soils and geology including:</i> <ol style="list-style-type: none"> <li>1. <i>Nature, distribution and thickness of made ground</i></li> <li>2. <i>Nature, degree and extent of potential contamination</i></li> <li>3. <i>Content of unacceptable material e.g. peat and biodegradable matter etc.</i></li> <li>4. <i>Suitability of the ground for the founding of structures</i></li> <li>5. <i>Engineering properties of the ground.</i></li> </ol>
TP1 – TP3	Former Crooklands Farm	

## **5.0 GROUND CONDITIONS**

### **5.1 *Surface Strata***

5.1.1 *These investigation works have identified topsoil present over the majority of the site area varying in thickness between 0.2 – 0.4m. Topsoil within this site is a valuable resource and subsequent chemical analysis will be required to determine its suitability for re-use within the garden areas and landscaped areas of the proposed development.*

5.1.2 *Made ground deposits have been identified within position TP01 and TP02 and have been proven to extend to depths between 0.3 – 0.7m bgl. The made ground material comprises of natural soils intermixed with anthropogenic materials such as brick, slate and plastic piping. No visual or olfactory evidence was identified within the made ground deposits however the presence of anthropogenic materials may indicate potential contaminants.*

### **5.2 *Natural Strata***

5.2.1 *The whole of the underlying natural strata comprises of firm to stiff clay which has been proven to a maximum depth of 2.9m bgl.*

5.2.2 *In-situ hand shear vane testing was carried out within the cohesive strata and has confirmed shear strength values between 17 - 120 kPa. Assessment of these results confirms that the brown firm to stiff clay will offer a safe bearing capacity in the order of 100kN/m<sup>2</sup> at a minimum depth of 0.9m bgl. We have noted extremely low values within position TP14 at 1.5m bgl. This low value is anticipated to be caused by a significant amount of granular material intermixed with the clay strata and ground water ingress causing a localised anomaly of the results.*

### **5.3 *Bedrock***

5.3.1 *Bedrock was not identified within any of the trial pit locations within this ground investigation.*

### **5.4 *Groundwater***

5.4.1 *Groundwater strikes have been identified within positions TP07, TP14 and TP27 at depths varying between 1.5 – 2.4m bgl. These water strikes are considered to represent perched water within the underlying natural strata and the local ground water table is considered to lie at a significant depth below the site within the underlying bedrock.*

5.4.2 *Whilst no significant water entries have been encountered during these investigations, it should however be acknowledged that localised groundwater may accumulate within the clay deposits and that this may locally result in flooding of deeper excavations and require localised sump pumping techniques. Whilst the management of groundwater during the excavation phase of work is not considered to represent a significant difficulty at this site, it is nevertheless possible that locally such management may be required.*

5.4.3 *Where perched water is encountered within granular units significant instability may occur and the foundations engineer should be consulted prior to continuing with excavations so as not to disrupt the underlying strata.*

## **5.5 Excavations**

- 5.5.1 *The shallow strata present within this site comprises of cohesive glacial till and it is anticipated that the excavations made within this site will be capable of remaining open for a significant period without side support. However sudden catastrophic collapse of any excavation should however be considered to represent a high risk.*
- 5.5.2 *Within position TP14 collapse was noted at depths between 1.5 – 2.2m bgl and this is anticipated to be caused by perched ground water. Again where perched ground water is encountered and causes instability excavation should cease and advice should be sought from the foundations engineer and the building inspector.*
- 5.5.3 *It is essential that personnel should not be allowed to approach or enter any excavation made upon this site unless appropriate precautions have been adopted. This is particularly important in respect of the necessary site preparation works, drainage and foundation works where personnel may be specifically required to enter excavations. All works should be carried out in accordance with the advice offered in HSG 150.*

## **5.6 Contamination**

- 5.6.1 *These investigations have not identified any deposits of made ground that may hold the potential for contamination. The underlying natural strata is not known to be affected by any significant naturally occurring environmental hazards. Chemical analysis has been carried out upon the topsoil material to determine its suitability for re-use on site within the proposed garden areas.*

## **5.7 Sampling**

- 5.7.1 *Based upon the initial site appraisal in conjunction with the findings of the intrusive investigations a series of representative samples of the strata encountered have been retained for laboratory analyses. These analyses have been intended to determine the potential presence of any contamination which may represent a hazard to site operatives or end users of the site. This section of the work is considered in more detail in section 6 of this report.*

## **5.8 SUDS**

- 5.8.1 *Assessment of the ground conditions present within this site in terms of sustainable urban drainage confirms the presence of effectively impermeable cohesive glacial till across the majority of the site area. It is our opinion based upon the results of these investigations that the natural superficial deposits within this site are considered to be impermeable and are not suitable for the use of a soakaway system of surface water disposal. It will be necessary for surface water to be disposed of utilising an adjacent existing drainage system.*

## **6.0 CONTAMINATION ANALYSIS & ASSESSMENT CRITERIA**

### **6.1 Sampling**

- 6.1.1 *A total of seventeen (17 No.) samples of strata encountered during these investigations have been retained for chemical analyses. Generally these samples relate to the shallow ground conditions located within the site. These samples are considered to be representative of the ground conditions within the site and form a basis for assessment of their potential for reuse within a residential environment.*

6.1.2 All samples obtained from this site were considered to be subject to a program of PAH analyses. Accordingly all samples have been placed into a 500ml wide necked brown glass jar. All soil samples have been stored in cool boxes at temperatures of approximately 4° (+ or - 2°C) until delivery to the selected laboratory. All sample containers were marked with the site address, trial pit or borehole number, depth and date of sampling. All samples have been tested within the specified handling period to accord with the sampling protocol presented by Exova Jones Laboratories.

## **6.2 Range**

6.2.1 Topsoil has been identified over the whole of the site and samples of this material have been obtained for analysis to determine its suitability for re-use within the proposed garden areas.

6.2.2 Localised made ground deposits have been identified within positions TP 01 and TP 02 and therefore the made ground material within this location has been analysed to determine whether its suitable for retention within the proposed residential development.

6.2.3 All trial pits have identified the presence of natural glacial till material directly underlying the surface topsoil or made ground. Reference to the initial desk study has confirmed that there are no records of naturally occurring elevated concentrations of any common contaminants present within the underlying strata. Accordingly the natural strata present within this site is considered to be suitable for retention within a residential environment.

## **6.3 Laboratory**

6.3.1 All samples selected for chemical analyses have been returned to Exova Jones Ltd., who are an MCERTS and UKAS accredited laboratory facility. Each sample has been subject to a range of chemical analyses to determine the concentrations of a wide range of common contaminants applicable to the former use of this site and the materials present. Details of the analysis program are shown in table 4 below. Confirmation of the UKAS and MCERTS accreditations for each test is indicated within the results which are appended to this report.

## **6.4 Development Proposals**

6.4.1 We understand that the site is to be re-developed by one hundred and sixty five (165 No.) residential properties with associated access road, parking, garden areas and POS.

## **6.5 Analysis Range**

6.5.1 The preliminary conceptual model identifies that there is the potential for a pollutant pathway linkage to be present at the site and that further assessment is required. Table 4 below confirms the range of analyses undertaken upon the samples of topsoil and made ground obtained from this site.

**Table 4: Chemical Testing Schedule**

<b>Analysis</b>	<b>Determinands</b>	<b>No. of Samples</b>
Metals	Arsenic, Cadmium, Chromium total, Copper, Lead, Mercury, Nickel, Selenium, Zinc	17
Organics	PAH – USEPA 16 suite, Phenol	17
Inorganics	Cyanide, Soluble sulphates, Sulphide, pH, TOC	17
Asbestos	Asbestos Screen	2

## 6.6 Results

6.6.1 Full details of the chemical analyses results are appended to this report for reference and should be read in conjunction with the comments and recommendations regarding risk assessments. Summaries of the test results are presented in conjunction with the current assessment criteria in Section 7 of this report.

## 6.7 Approach

6.7.1 The current UK approach to the consideration of contaminated land is based upon the principles of risk assessment. This in turn is founded upon the use of a source-pathway-target principle in order to establish the presence of a potential pollutant linkage. Our approach to the risk assessment is consistent with UK guidance and best practice. As advocated in the EA Policy Statement: Guidelines for Environmental Risk Assessment and Management a tiered approach has been adopted. This tiered approach is central to Part IIA of the Environmental Protection Act 1990 and the Town and Country Planning Act 1990.

## 6.8 Site Classification

6.8.1 The current development proposals for this site confirm that the site will be developed on a private residential basis with associated private garden areas. Accordingly the site usage has been considered on the basis of an end land use of residential as defined by EA Science Report SC050021/SR3 2009 in relation to the most recent soil guideline values.

## 6.9 Criteria

6.9.1 The concentrations of contaminants within the ground have been compared to a range of generic soil guideline values that have been prepared by DEFRA and the Environment Agency. Where published, soil guideline values (SGV) have been utilised as intervention values for the purpose of an initial tier 1 assessment.

6.9.2 At the time of the preparation of this report soil guideline values were available only for a limited number of contaminants and the development of both the CLEA model and additional soil guideline values is on-going. Where published soil guideline values are available they have been utilised as intervention values for the purposes of an initial tier 1 assessment. A number of SGV's have recently been updated to reflect a modern approach to the protection of human health.

- 6.9.3 *In March 2014 the Department for Environment Food & Rural Affairs published SP1010 : Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination Policy Companion Document. This document provides a series of Category 4 screening levels based upon differing land uses. Reference has been made to the values presented within this report in relation to the appropriate land usage.*
- 6.9.4 *Where soil guideline values were not published at the time of preparing this report, generic assessment criteria (GAC) published by Land Quality Management Ltd., in conjunction with the Chartered Institute Of Environmental Health have been adopted. The values published in the LQM/CIEH S4UL for "Human Health Risk Assessment" Registration Number S4UL 3265.*
- 6.9.5 *Reference has also been made to published soil screening values presented by Atkins Ltd., under their Atrisk Subscription Service. The SSVs have been adopted where SGVs or GACs are not available. The remaining contaminants have been considered based upon information that was the best available at the time of the study.*

## **7.0 RESULTS OF ANALYSIS & QUALITATIVE RISK ASSESSMENT**

### **7.1. Model**

- 7.1.1 *As discussed above, assessment of contaminated land is based upon a simple assessment of pollutant linkages referred to as the source-pathway-target model. This assessment considers the current or proposed usage of the site in terms of suitability for use. This implies the use of risk assessment in principle in order to evaluate the potential effects and concerns of contamination on a site-specific basis.*
- 7.1.2 *Initial assessment of the chemical analyses results has been undertaken to assess the concentrations of determinands in relation to tier 1 assessment criteria. The summary of these test results is detailed below.*

### **7.2 Results Summary**

- 7.2.1 *The samples were all obtained from the topsoil and made ground strata from across the site. Tables 5 - 6 have been prepared as a summary of the laboratory analyses depending upon the class of analyses undertaken and the strata type present. The test results have been compared to the adopted assessment criteria, relating to a proposed residential with home grown produce land usage.*

### **7.3 Metals & Inorganics**

- 7.3.1 *Table 5 below indicates the range of contaminants that were analysed and their respective assessment criteria. Chemical analysis has confirmed that all concentrations are below the adopted assessment criteria and therefore there it is considered that there is no requirement for remediation in terms of metals and inorganics.*



<b>Table 5: Summary of Contamination Analysis: Metals &amp; Inorganics</b>					
	<b>No. of Samples</b>	<b>Range of Values (mg/kg)</b>	<b>Assessment Criteria (mg/kg)</b>	<b>No. of Samples Failing</b>	<b>Locations</b>
Arsenic	17	1.1 – 10.6	37 <sup>3</sup>	0	-
Cadmium	17	<0.1 – 0.2	11.0 <sup>3</sup>	0	-
Chromium (total)	17	13.2 – 72.8	910 <sup>3</sup>	0	-
Copper	17	5.0 – 38.0	2400 <sup>3</sup>	0	-
Lead	17	12.0 – 52.0	200 <sup>1</sup>	0	-
Mercury	17	<0.1	40 <sup>3</sup>	0	-
Nickel	17	7.3 – 32.1	180 <sup>3</sup>	0	-
Selenium	17	<1.0	250 <sup>3</sup>	0	-
Zinc	17	17.0 – 105.0	3700 <sup>3</sup>	0	-
Total Cyanide	17	<0.5	34.2 <sup>2</sup>	0	-
Phenol	17	<0.15 – 0.26	120 <sup>3</sup>	0	-
pH	17	5.88 – 8.41	-	0	-
SOM	17	0.3 – 4.95	-	0	-
SO <sub>4</sub> (2:1)	17	<0.001 – 0.01	0.5 <sup>5</sup>	0	-
Asbestos	2	ND	Present/absent	0	-

<sup>1</sup> DEFRA : SP1010 : Category 4 Screening Levels  
<sup>2</sup> Atkins Atrisk SSV residential without home grown produce (1% SOM)  
<sup>3</sup> LQM and CIEH S4UL's for Human Health Risk Assessment (Registration No. S4UL 3265) residential with home grown produce (1% SOM)  
<sup>4</sup> BRE Special Digest 1:2005 DS-1  
 ND – None Detected

## 7.4 Speciated PAH

7.4.1 The soil samples retained from the site investigation have been subject to a programme of analyses which have assessed the concentrations of the individual constituents of the polycyclic aromatic hydrocarbon series. A summary of these results is shown in table 6. The assessment criteria utilised are based upon the presence of 1.0% soil organic matter within the samples generally. Reference to the tests results does however show more variable soil organic matter content.

7.4.2 Assessment of table 6 below identifies that no of samples obtained from this site contain any significant concentrations of PAH compounds.

<b>Table 6: Summary of Contamination Analysis: Organics: PAH USEPA 16 Suite</b>					
	<b>No. of Samples</b>	<b>Range of Values (mg/kg)</b>	<b>Assessment Criteria<sup>1</sup> (mg/kg)</b>	<b>No. of Samples Failing</b>	<b>Locations</b>
Acenaphthene	17	<0.05	210	0	-
Acenaphthylene	17	<0.03	170	0	-
Anthracene	17	<0.04	2400	0	-
Benzo{a}anthracene	17	<0.06 – 0.13	7.2	0	-
Benzo{a}pyrene	17	<0.04 – 0.12	5.0 <sup>2</sup>	0	-
Benzo{b}fluoranthene	17	<0.05 – 0.17	2.6	0	-
Benzo{ghi}perylene	17	<0.04 – 0.1	320	0	-
Benzo{k}fluoranthene	17	<0.02 – 0.07	77.0	0	-
Chrysene	17	<0.02 – 0.11	15.0	0	-
Dibenz{ah}anthracene	17	<0.04	0.24	0	-
Fluoranthene	17	<0.03 – 0.21	280	0	-
Fluorene	17	<0.04 - <0.04	170	0	-
Indeno{123-cd}pyrene	17	<0.04 – 0.11	27.0	0	-
Naphthalene	17	<0.04	2.3	0	-
Phenanthrene	17	<0.03 – 0.08	95.0	0	-
Pyrene	17	<0.03 – 0.18	620	0	-

<sup>1</sup> LQM & CIEH S4UL's for human health risk assessment (Registration No. S4UL 3265) – Residential with home grown produce (1% SOM)  
<sup>2</sup> DEFRA : SP1010 : Category 4 Screening Levels

## **7.5 Sulphates**

7.5.1 *Within the program of laboratory testing each sample has also been analysed to determine the concentration of water soluble sulphates within the ground. Reference to the laboratory results presented by Exova Jones confirms that soluble sulphates are present at concentrations between <0.001 – 0.01g/l. Reference to BRE Special Publication 1 : 2005 “Concrete in Aggressive Ground” confirms that at <0.5g/l, the ACEC class for this site is assessed to be AC-1s on the basis that static water is present with a PAH >2.5. Reference to table D1 of BRE Publication confirms that the ground concrete and mortar should be designed to a DC-1 class.*

## **7.6 Index Properties**

7.6.1 *A total of sixteen (16 No.) samples of natural clay strata encountered during these investigations have been returned to a civil engineering laboratory to determine their index properties. Copies of the laboratory tests are appended to this report for reference. Consideration of these results confirms that generally the clay soils within the site have a plasticity index in the range of 21% - 27%. Based upon these plasticity indexes the clay material within the site is considered to have a medium volume change potential in accordance with the NHBC Handbook Chapter 4.2. Therefore all clays within this site should be considered to have a medium volume change potential.*

## **7.7 Ground Gas**

7.7.1 *The initial phase I desk study has not identified any on site or off site sources of explosive or toxic gases that may impact upon the site. These investigations have not identified any localised bio-degradable materials likely to generate ground gases within the site. Therefore we consider that this site is not at risk from ground gases generated within the site or from off-site sources and it is considered to be characteristic situation 1 (NHBC Green). Therefore no ground gas precautions are required within the properties within this development.*

## **8.0 DISCUSSIONS**

### **8.1 General**

8.1.1 *The desk study undertaken by this practice has identified that the site has remained in agricultural usage up until the present day. As part of these ground investigation works an initial walkover survey has confirmed that the site is similar condition to that of the previous desk study.*

8.1.2 *The results of the chemical analyses undertaken upon representative samples of strata obtained from this site have been assessed in Section 7 above and subject to further discussion below.*

### **8.2 Metals & Inorganics**

8.2.1 *The chemical analysis has not identified any elevated concentrations of the determinands tested above the adopted assessment criteria for the topsoil and the made ground strata. Therefore the topsoil strata within the site is considered suitable for re-use within the proposed garden and POS areas of the development and the made ground material is considered suitable for retention within the development area.*

### 8.3 PAH Suite

8.3.1 The analysis has identified no exceedances of various PAH factions within the topsoil and made ground strata and does not pose a potential hazard to the long term end users of the site. No specific remediation in terms of PAH factions is required.

### 8.4 Revised Conceptual Site Model

8.4.1 As a result of these intrusive ground investigations and subsequent program of chemical analyses, it has been possible to revise the preliminary conceptual site model presented in Section 3. The revised conceptual site model is now shown in table 7 below. This report adopts the methodology for risk evaluation presented in CIRIA report C552 'Contaminated Land Risk Assessment – A Guide to Good Practice', 2001. The method is qualitative and involves the classification of the following:

8.4.2 In the context of regulatory definition of 'Contaminated Land' (as defined by the EPA 1990), 'very high' and 'high' risks would fall under the classification of 'Contaminated Land'. 'Moderate' risk could also potentially be classified as 'Contaminated Land' but any lower risk rating would not. Thus the following potential exposure pathways between potential and known contaminant sources based on information provided to date and receptors are tentatively identified in table 7 below.

Table 7: Revised Conceptual Site Model						
Potential Source	Potential Receptor	Possible Pathway	Probability	Consequence	Risk	Mitigation
Unsuitable made ground material	Site personnel during construction	Direct contact of soils Inhalation or ingestion of soil / dust	Li	Mi	Moderate/Low	No requirement for a formal remediation strategy. Topsoil suitable for reuse within the proposed development.
	Future site users	Direct contact of soils Inhalation or ingestion of soil / dust	UI	Md	Low	
	Surface water in the vicinity of the site	Leaching of contaminants through drainage system	UI	Md	Low	
	Ground water in aquifer	Leaching of contaminants to ground water	UI	Md	Low	
	Future site users	Vapour migration from soils	Lw	Mr	Very Low	
	Proposed buildings and services	Direct contact with contaminated soils	Lw	Mi	Low	
	Plants in gardens and soft landscaping	Direct contact	Lw	Mi	Low	
Contaminated ground water	Site personnel during construction	Water entering excavations	Lw	Mi	Low	Considered unlikely to be present
	Future site Users	Retained surface water	Lw	Mi	Low	
Toxic and explosive gasses	Proposed buildings and occupiers	Ground gas migration into buildings	UI	Md	Low	No gas precautions will be required.
Radon gas	Proposed buildings and occupiers	Ground gas migration into buildings	UI	Sv	Very Low	No radon precautions required
Key: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, UI = Unlikely						

## **8.5 Preliminary Proposals**

- 8.5.1 *This ground investigation has not identified any elevated concentrations of the determinands within the topsoil material and made ground material. Therefore the topsoil material within the site is considered suitable for re-use within the private garden and POS areas of the development and the made ground strata suitable for retention. No formal remediation strategy is required for this development site.*
- 8.5.2 *Copies of this ground investigation report should be presented to the regulatory authorities for confirmation of their acceptance of these recommendations.*

## **8.6 Foundations**

- 8.6.1 *Based upon the results of this ground investigation foundations may be formed within the shallow natural strata. The cohesive glacial till is considered to offer a safe bearing capacity in the order of 100kN/m<sup>2</sup> at a minimum depth of 0.9m.*
- 8.6.2 *It is anticipated that traditional strip type foundations will be applicable to the proposed residential properties within this site. It is anticipated that foundations will generally be formed at depths varying between 0.9 – 1.5m bgl.*
- 8.6.3 *Where areas of tree influences are present, it may be necessary to consider foundations extending to increased depths within the clay strata in accordance with the requirements of the NHBC Handbook Chapter 4.2. Laboratory testing has demonstrated that the clay strata within this site is considered to have a medium volume change potential in accordance with NHBC chapter 4.2 and therefore this information should be utilised in conjunction with the tree types and geometry of the site layout to determine likely foundation depths.*

## **8.7 Ground Floor Construction**

- 8.7.1 *It is recommended that all properties within this site should be provided with a suspended ground floor construction. This may be of a specialist manufactured pre cast concrete beam and block type or of a designed cast insitu construction. It is recommended within the areas of tree root influences that a beam and block floor utilising an appropriate air void be adopted in accordance with the recommendations made by the NHBC. In all other areas it will be possible to utilise a cast insitu ground floor construction if required.*

## **8.8 Precautions**

- 8.8.1 *Whilst these investigations have not located any evidence of widespread suspicious or unusual ground conditions, it is important to recognise that should such features become evident during the development process, they should be drawn to the attention of the appropriate authorities before proceeding. It is important that inspection, sampling and testing of any unusual materials encountered within the site is undertaken of the site to ensure that these do not represent a hazard to site operatives of final end users.*

## **9.0 CONCLUSIONS & RECOMMENDATIONS**

### **9.1 Remediation**

- 9.1.1 *The topsoil analysed has not identified any elevated concentrations of the determinands tested and therefore is suitable for reuse within the private garden areas of this proposed development.*
- 9.1.2 *The made ground material analysed has not identified any elevated concentrations and therefore is considered suitable for retention within the proposed site and no formal remediation strategy is required for this development.*

### **9.2 Foundations**

- 9.2.1 *Based upon the results of this ground investigation foundations may be formed within the shallow natural strata. The cohesive glacial till is considered to offer a safe bearing capacity in the order of 100kN/m<sup>2</sup> at a minimum depth of 0.9m.*
- 9.2.2 *It is anticipated that traditional strip type foundations will be applicable to the proposed residential properties within this site. It is anticipated that foundations will generally be formed at depths varying between 0.9 – 1.5m bgl.*
- 9.2.3 *Where areas of tree influences are present, it may be necessary to consider foundations extending to increased depths within the clay strata in accordance with the requirements of the NHBC Handbook Chapter 4.2. Laboratory testing has demonstrated that the clay strata within this site is considered to have a medium volume change potential in accordance with NHBC chapter 4.2 and therefore this information should be utilised in conjunction with the tree types and geometry of the site layout to determine likely foundation depths. Tree root effects may cause foundations to extend to 2.5m bgl.*

### **9.3 Ground Floor Construction**

- 9.3.1 *It is recommended that all properties within this site should be provided with a suspended ground floor construction. This may be of a specialist manufactured precast concrete beam and block type, or of a designed cast insitu construction. In those areas which may be affected by tree root influences it is important that a suitable air void be provided below ground floor construction and as such in those areas it will be necessary to utilise a pre cast concrete beam and block type arrangement. In all other areas of the site a cast insitu reinforced concrete construction may be adopted.*

### **9.4 SUDS**

- 9.4.1 *The superficial deposits present within this site have been confirmed to comprise glacial till material consisting of firm to stiff slightly sandy slightly gravelly clays. This type of strata is considered to be effectively impermeable and is not conducive to the adoption of a soakaway system of surface water disposal. It will therefore be necessary for the surface water at this site to be disposed of at an appropriate drainage point outside the site area.*

## **9.5 Further Works**

9.5.1 *If any unusual or suspicious strata or ground conditions are encountered during the subsequent site stripping and preparation work, it will be necessary for these areas to be brought to the attention of the appropriate authorities so that all necessary inspection, sampling and testing may be undertaken to determine whether these materials represent a hazard to human health. It is incumbent upon the site contractors to advise a responsible authority of any unusual findings within the site which may then be further investigated.*

## **10.0 NOTES**

- 10.1** *All reports are for advisory purposes only and all design decisions are the ultimate responsibility of others.*
- 10.2** *Unless stated otherwise the investigation has been undertaken in general accordance with the recommendations given in BS 5930 : 1999 "A Code of Practice for site Investigations" and the laboratory testing has been carried out in accordance with BS 1377 : 1990 "Methods of Test for Civil Engineering Purposes".*
- 10.3** *Soil and rock descriptions are generally based on the scales of strength and relative density within BS 5930 although it should be noted that in certain circumstances descriptions are based on site records or a qualitative assessment without the benefit of in-situ or laboratory test results.*
- 10.4** *The assessment of ground conditions given in this report is based on the results of the fieldwork and laboratory testing carried out and there may be other conditions at the site not encountered by these works, which have not been taken into account.*
- 10.5** *The scope of the investigation and information provided may not necessarily reflect all the geotechnical and environmental aspects related to the site, and the omission of certain items does not mean that the site is unaffected by such problems.*
- 10.6** *It should be noted that groundwater levels can vary and may at times be significantly different to those recorded during the investigation and attention is drawn to BS 5930 which indicates that measurements may be necessary over an extended period of time to investigate changes in groundwater pressures due to seasonal, tidal and other causes.*
- 10.7** *Any recommendations on construction methods within this report are for initial guidance only and all design proposals remain the responsibility of the appropriate contractor/consultant.*
- 10.8** *Further assessment, investigation, construction activities or time may reveal conditions that were not found during the period of investigation and, therefore, could not have been taken into account in the preparation of the report and where such information might impact upon the stated opinion R. E. Fry & Associates Ltd request the opportunity to review such information and modify the report if necessary.*
- 10.9** *Where information has been obtained from sources other than the direct findings of the investigation, R. E. Fry & Associates Ltd cannot and does not guarantee the authenticity or reliability of this information.*
- 10.10** *Where opinions expressed in this report are based on current available guidelines and legislation, no liability can be accepted by R. E. Fry & Associates Ltd for the effects of any future changes to such guidelines and legislation.*

**10.11** *This report has been prepared on the instructions and to the requirements of the named client and any unauthorised party using this information for any purpose does so at his own risk and any duty of care to that party is excluded.*

*Signed for and on behalf of*  
**R E FRY & ASSOCIATES LIMITED**



*M Davies B Sc (Hons)*

*Signed for and on behalf of*  
**R E FRY & ASSOCIATES LIMITED**



*R E FRY B Sc (Hons), C Eng., MI Struct.E., M.a.P.S.*