



Geo-Environmental

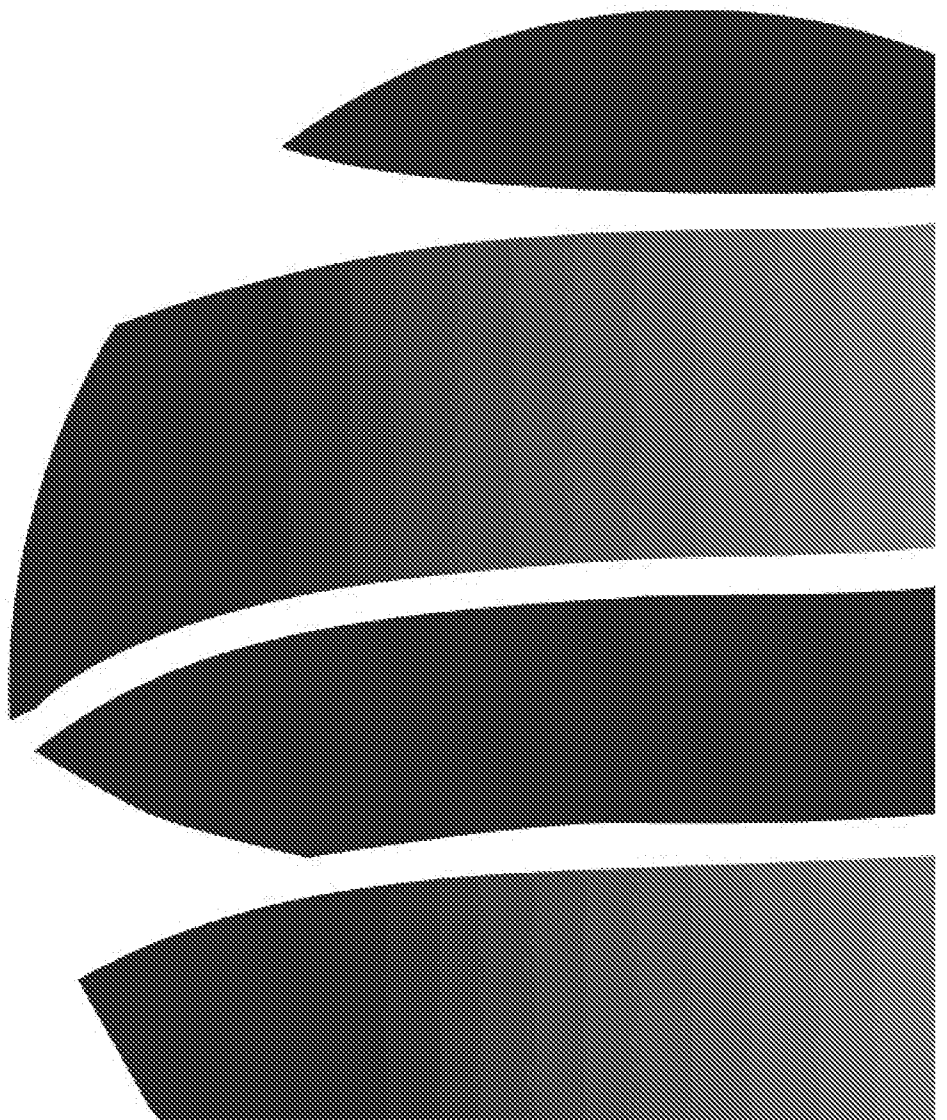
GROUND INVESTIGATION REPORT

for the site at

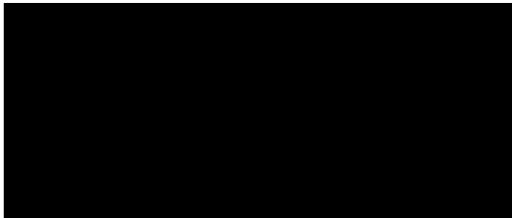
**ANGELS NURSERY,
YAPTON ROAD, BARNHAM,
WEST SUSSEX, PO22 0AY**

on behalf of

LOVELL PARTNERSHIPS LIMITED





Report:	GROUND INVESTIGATION REPORT
Site:	ANGELS NURSERY, YAPTON ROAD, BARNHAM
Client:	LOVELL PARTNERSHIPS LIMITED
Date:	10/09/2015
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EXECUTIVE SUMMARY		
Site Details	Site Address	Angels Nursery, Yapton Road, Barnham, West Sussex, PO22 0AY
	National Grid Reference	496260, 104030
	Site Area	3.5Ha
	Form of Development	Construction of private houses with gardens, communal soft landscaping, retention pond, estate roads and associated development infrastructure.
Encountered Conditions	Scope of works	The assessment incorporated a desk study to determine the site's setting to inform a preliminary risk assessment followed by an intrusive investigation to confirm the ground and groundwater conditions and support the development of geotechnical and geo-environmental assessments of the site in relation to the proposed development.
	Ground Conditions	The ground conditions comprised a limited thickness of Topsoil and/or Made Ground overlying the River Terrace Deposits. The underlying London Clay was not proved in any of the trial pits.
	Groundwater	Groundwater was encountered in all of the trial pits and window sampler boreholes within the River Terrace Deposits during the intrusive investigation. Subsequent monitoring did not record any groundwater, although this was during a protracted period of dry weather
Geotechnical Considerations	Foundations	Conventional strip foundations are considered to be suitable for the proposed development, terminating within the granular horizons of the River Terrace Deposits, and extending through any Made Ground, disturbed, reworked, desiccated ground or root zones. It is possible that groundwater ingress may occur during excavation for deeper foundations, especially if construction takes place during winter months or prolonged wet periods. Void former or compressible media should be included where foundations exceed 1.5m bgl, i.e. in line with NHBC guidance. Where the ground and/or site conditions are such that foundations in excess of 2.5m depth would be required, it is considered that options include the use of engineer designed deep strip, as defined in NHBC Standards, or piled foundations. Location specific foundations may need to be considered where the existing drainage ditches are to be removed.
	Floor Slabs	Suspended floor slabs are recommended throughout the development.
	Excavations	Both shallow and deeper excavations within the cohesive horizons of River Terrace Deposits are likely to remain marginally stable in the short and medium term. Both shallow and deeper excavations within the granular horizons of River Terrace Deposits are unlikely to remain stable. Any excavations which encounter water are likely to become unstable rapidly.
	Drainage	Trial pit soakage tests have indicated that soakaways are unlikely to perform satisfactorily on site. Alternative options could include connection to the mains network, or SUDs type solutions such as permeable pavements, on-site storage and attenuated discharge to the ground, swales, detention basins or the like.

	Buried Concrete	Buried concrete for shallow foundations should be designed to Class DS1 (AC1).
Environmental Considerations	Human Health	Evidence of localised PAH contamination was encountered within Made Ground. However, given the poor physical quality of soils in that area of the site they should be considered unsuitable for re-use in private gardens and removed in accordance with a remediation method statement. The garden areas should be completed with suitable subsoil and Topsoil.
	Groundwater	No evidence of mobile contamination was encountered within the soils. In the absence of any specific pollutant linkages, no risk mitigation measures are considered to be required.
	Ground Gases	Based on the results of the gas monitoring, within the site, the gassing regime is considered representative of Characteristic Situation 1 (CIRIA/BS) and Green (NHBC). On this basis, it is considered that no gas protection measures are required.
	Radon Gas	No radon protection measures are required.
	Built Environment	The use of barrier pipe may be required to protect the built environment. It is recommended that the results of this investigation are presented to the water utility company in order to confirm the pipe material.
	Waste Disposal	Two WAC tests were undertaken on the Made Ground. One result marginally exceeded the acceptance criteria for inert waste. The results of a single analysis on natural soils classified them as inert waste. Where soils are to be disposed of off-site the results of the chemical analysis should be provided to the proposed receptor site for confirmation of the classification.
Further Action: • Preparation of a remediation method statement to set out the strategy and measures to remove PAH impacted and poor quality soils from gardens. • Validation of the removal of unsuitable soils from gardens in the vicinity of WS6 and replacement with suitable subsoil and Topsoil. • Provision of a validation report on completion of the remediation works. • A discovery strategy should be maintained during development such that any abnormal conditions (geotechnical or potential contamination) are identified and their potential impact on the proposed development assessed prior to determining any potential mitigation measures. <i>This Executive Summary is intended to provide a brief summary of the main findings and conclusions of the investigation. For detailed information, the reader is referred to the main report ref. GE10423/GIR/SEP15.</i>		



1.0 INTRODUCTION

1.1 General

Geo-Environmental Services Limited (Geo-Environmental) was instructed by Lovell Partnerships Ltd to undertake an investigation of the geotechnical and geo-environmental factors pertaining to proposed development at Angels Nursery, Yapton Road, Barnham, PO22 0AY (the site). The site's location is presented in Figure 1.

1.2 Form of Development

It is understood that the proposed development is to comprise the construction of private houses with gardens, communal soft landscaping, detention pond, estate roads and associated development infrastructure.

1.3 Objectives

The investigation was to comprise a desk study of geotechnical and environmental factors pertaining to the site, including a site walkover, a review of available historical maps and an examination of other sources of geo-environmental and geotechnical information. Subject to findings of the desk study, an intrusive investigation was to be undertaken into the geotechnical and geo-environmental conditions pertaining to the site.

The data from the geotechnical investigation was to form the basis of an interpretation with respect to foundation design, pavement construction, soakaways, concrete specification, excavation stability and other pertinent construction issues.

A Preliminary Risk Assessment (PRA) was undertaken as part of the desk study in accordance with CLR11, in order to provide a basis for the scope and rationale of the subsequent Phase II ground investigation. The data from Phase I and Phase II were then to form the basis of a subsequent Tier 1 Generic Quantitative Risk Assessment (GQRA). The objective of the risk assessment process was to evaluate the risks posed to the proposed redevelopment, adjacent land uses and the wider environment, in the context of likely planning requirements, immediate liabilities under the Environment Act 1990 and risks posed to Controlled Waters under the Water Resources Act.

1.4 Standards

Where practicable, the ground investigation and subsequent geotechnical and environmental assessments were undertaken in accordance with the following documents and guidance:

- National Planning Policy Framework – March 2012;
- Planning Policy Statement 23 – Planning and Pollution Control;
- Model Procedures for the Management of Contaminated Land, CLR11, DEFRA and Environment Agency 2004;
- Environment Agency Guidance on Requirements for Land Contamination Reports, Version 1 dated July 2005;
- BS10175:2011 - Investigation of Potentially Contaminated Sites - Code of Practice, BSI 2011;
- BS5930: 2015 - Code of Practice for Site Investigations, BSI 2015;
- EN ISO 14688 Geotechnical Investigation and Testing Part 1-2002 and Part 2-2004;
- BS1377: 1990 - Soils for Civil Engineering Purposes, BSI1990;
- NHBC Standards Chapter 4.1 Land Quality - Managing Ground Conditions, September 1999;
- NHBC Standards Chapter 4.2 Building Near Trees;
- CIRIA C665 Assessing risks posed by hazardous ground gases to buildings (2007);



- NHBC 10627-R01(04) Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present (2007);
- BS8485:2007 Code of practice for the characterisation and remediation from ground gas in affected developments.
- BS8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

1.5 Conditions

This report does not purport to be a “Geotechnical Design Report” as defined in Clause 2.8 of Eurocode 7 (Geotechnical Design BS EN 1997-1:2004) and some of the data used to support this preliminary geotechnical assessment may not be fully compliant with that design code. It is considered possible that further detailed ground investigations could be required to facilitate the detailed geotechnical design process and should be carried out on a structure specific basis if necessary.

The data collected from the investigations have been used to provide an interpretation of the geotechnical and/or environmental conditions pertaining to the site. The recommendations and opinions expressed in this report are based on the data obtained. Geo-Environmental takes no responsibility for conditions that either have not been revealed in the available records, or that occur between or under points of physical investigation. Whilst every effort has been made to interpret the conditions, such information is only indicative and liability cannot be accepted for its accuracy.

It should be noted that in particular the concentrations and levels of mobile liquid and gaseous materials are likely to vary with time. The results obtained may therefore only be representative of the conditions at the time of sampling. This report should not be taken as any guarantee that a site is free of hazardous or potentially contaminative materials.

Information contained in this report is intended for the use of the Client and Geo-Environmental can take no responsibility for the use of this information by any party for uses other than that described in this report. Geo-Environmental makes no warranty or representation whatsoever express or implied with respect to the use of this information by any third party. Geo-Environmental does not indemnify the Client or any third parties against any dispute or claim arising from any finding or other result of this investigation report or any consequential losses.

Assessment criteria or other parameters developed for the evaluation of contamination on this site are based on a number of assumptions regarding exposure and toxicology. Exposure to contaminants and levels of adverse effects may therefore vary. Whilst reasonable care and expertise has been employed in the development of such criteria, no liability is accepted in this respect. Other criteria or guidance on the development of assessment criteria may be published in the future and no liability is accepted in this respect.

2.0 DESK STUDY

The findings of the Phase I desk study are presented in the following section. A copy of the historical maps and other information obtained as part of the desk study are presented in Appendix A. Comments made in the following section regarding possible ground conditions on the site are based purely on the desk study.

2.1 Site Description

The site comprised an approximately rectangular shaped parcel of land extending to approximately 3.5Ha located at NGR 496260 104030. The ground levels across the site were relatively uniform with typical levels (taken from the topographic survey) within the site ranging from 8.05m to 9.25m Above Ordnance Datum (AOD) in the northern and southern portions of the site respectively.

At the time of the intrusive investigation, June 2015, the site was vacant and comprised a former plant nursery. The majority of the site was generally overgrown with grass and brambles. A series of ditches ran parallel to each other from north to south in the southern portion of the site. Several rows and individual mature trees were scattered throughout the site. A two-storey vacant brick building was located to the east of the nursery access road in the north-eastern portion of the site. The access was off Yapton Road via an overgrown access track which extended towards the centre of the site.

The central and north-western portions of the site comprised an area of open space with heavily disturbed ground which contained fragments of brick, concrete, cast iron, reinforcing bars and the like. The existing tarmac road which ran from north to south through the centre of the site was partly obscured by the mixture of topsoil and demolition rubble. Along the road, several rectangular concrete footprints, presumably of the removed nursery buildings, were observed. In the southern portion of the site, the access track branched off towards the western portion of the site with a concrete crossing located over the drainage ditch.

The site was accessed via Yapton Road to the north. Heras fencing and concrete barriers blocked the entrance to the site with hedgerows and lines of trees forming the eastern, western and southern boundaries.

The surrounding area comprised mostly open fields with clusters of residential properties. The village of Barnham was located to the northwest. The site was bounded to the north by Yapton Road with residential properties and open beyond, caravan site to the east, community hall to the west and a series of nurseries to the south.

2.2 Geology

With reference to British Geological Survey (BGS) mapping, the geology of the site was anticipated to comprise River Terrace Deposits over London Clay. Given the former development of the site as well as the adjacent sites, Made Ground was expected to be present in certain parts of the site.

The term **Made Ground** is used to describe material which has been placed by man either for a particular purpose e.g. to form an embankment, or to dispose of unwanted material. For the former use, the Made Ground may well have been selected for the purpose and placed and compacted in a controlled manner. With the latter, great variations in material type, thickness and degree of compaction invariably occur and there can be deleterious or harmful matter, as well as potentially methanogenic organic material. The BSI Code of Practice for Foundations, BS8004:1986 Clause 2.2.2.3.5 Made Ground and Fill, includes the caveat that "all made ground should be treated as suspect, because of the likelihood of extreme variability".



The rivers of the south-east of England, including those along the south coast, have been subject to several changes of level since Pleistocene times. One result has been the formation of a complex series of **River Terrace Deposits**. The deposits are generally found at an elevation close to or higher than that of the existing rivers, and generally comprise sand and gravel of roughly bedded flint or chert.

In the south coast/Solent region, the **London Clay Formation** is characterised by firm to stiff grey fissured clay, weathering to brown near surface, with interbedded and/or sub-ordinate beds of sand. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. Crystals of gypsum (Selenite) are often found within the weathered part of the London Clay, and precautions against sulphate attack to concrete are sometimes required.

2.3 Hydrogeology

With reference to the Envirocheck dataset, the underlying bedrock geology was recorded as Unproductive Strata. These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

The overlying superficial deposits were designated as a Secondary 'A' aquifer. These aquifers consist of permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

The site is indicated to be outside of any Source Protection Zone (SPZ). An SPZ is a protection zone placed around a well or borehole that supplies groundwater of potable quality.

- Zone I - Travel time (of water) of 50 days or less to the groundwater source.
- Zone II - Either 25% of the source area or a travel time of 400 days whichever is greater.
- Zone III - The total area needed to support the discharge and abstraction from the protected groundwater source.

Two discharge consents to land were identified within a radius of 250m of the site boundary, details of which are provided in Table 2.1 below.

Operator	Location	Description	Distance from site
Fleurie Nursery Ltd	Fleurie Nursery, Yapton Road, Barnham, Bognor Regis, West Sussex, PO22 0AY	Trade Discharge – Process Water from Mixed Farming – Revoked.	94m E
Christopher Holmes	Hedgehog Plants, 39 Hill Lane, Barnham, Bognor Regis, PO22 0AY	Trade Discharge – Process Water from Undefined Property – New Consent	111m SW

Table 2.1 Summary of Discharge Consents

No pollution incidents to controlled waters were identified with a radius of 250m of the site boundary.

Three licensed groundwater abstractions were recorded within a radius of 1km of the site boundary, details of which are provided in Table 2.2 below.



Operator	Location	Description	Distance from site
Mr R Lonsdale	Point A at Tile Barn Farm, Banham	General Agriculture: Spray Irrigation – Direct	279m SE
Eric Wall Holdings Ltd	Point A, Lake Lane, Barnham	Horticulture and Nurseries: Spray Irrigation – Direct	591m NE
Eric Wall Holdings Ltd	Point B, Lake Lane, Barnham	Horticulture and Nurseries: Spray Irrigation – Direct	873m NE

Table 2.2 Summary of Groundwater Abstractions

2.4 Hydrology

With reference to the Landmark dataset, the closest surface water feature was a drainage ditch located within the site boundaries.

The site was indicated to be located outside of any current indicative tidal and fluvial flood plain, or any associated flood warning area.

No discharge consents or pollution incidents to controlled waters were recorded within a 250m radius of the site boundary.

Furthermore, no licensed surface water abstractions were identified as part of the desk study within a 1km radius of the site boundary.

2.5 Historical Data

A summary of site history dating back to 1877 is presented in Table 2.3 and has been determined through examination of historic maps obtained as part of the desk study.



Date	On Site	Off Site
1877-1880	The site comprised open space and formed part of a field network. An unnamed road ran along the northern boundary of the site.	The surrounding area comprised mostly open fields with occasional residential properties. The South Coast Railway line ran from east to west approximately 220m to the north of the site. A flour windmill was located c.480m to the east of the site.
1897-1899	No changes shown.	Limited residential development was shown to the west of the site. A nursery was shown immediately to the north of the site with a series of greenhouses and tanks within its boundaries. A smithy was shown c.160m to the northwest of the site. A further two nurseries were located approximately 500m to the northwest and 600m to the southwest.
1912-1914	No changes shown.	Further residential development was shown to the west and northwest of the site. The smithy on the 1897-1899 map extracts was no longer shown. A brickfield was noted c. 180m to the east of the site.
1938-1951	The site was divided into four individual plots of land with several small properties located within the boundaries.	Limited residential development of the surrounding area was shown. A disused canal was shown c. 250m south of the site labelled as 'Chichester and Arundel Canal'. A further three nurseries were shown c.250m to 750m to the northeast. The brickfield on the 1912-1914 map extracts was redeveloped as residential properties.
1947-1949	(Historical Aerial Photograph). No changes shown.	(Historical Aerial Photograph). No significant changes shown.
1961-1967	No changes shown.	No significant changes shown.
1974-1975	The site was shown to be developed as a nursery. An access track ran from Yapton Road located on the northern boundary of the site towards the centre of the site and then branched off towards the west. A series of four large and two smaller greenhouses were shown in the eastern portion of the site. Further small square and rectangular buildings were located in the central portion of the site as well as two semi-detached houses located near the northern boundary of the site. The southern and western portions of the site remained undeveloped.	Limited residential development was shown to the west of the site. A series of nurseries was shown immediately to the south of the site. Several new greenhouses and a 'tank' (presumably a water supply) were also shown c.100m to the east and immediately to the west of the site.
1978-1986	A drain was shown to run from north to south across the site.	Further limited residential development of the surrounding area was shown. Changes were noted to the layout of some of the nurseries previously shown within a 500m radius of the site. Works building and a warehouse were shown c.450m to the northwest.

1986-1994	Changes were shown to the footprint of several of the greenhouses on site. Two new large rectangular greenhouses were noted in the central portion of the site, replacing some of the smaller structures.	Some residential development of the area northwest of the site. Otherwise no significant changes shown.
2006-2014	Changes were noted to the layout and extent of the greenhouses on site. Two large rectangular structures were shown in the southern portion of the site, presumed to be buildings associated with the use of site as a nursery.	Greenhouses previously noted immediately to the west of the site boundary were no longer shown. Instead a village hall was noted. The nursery complex located approximately 300m to the northeast increased in size significantly with additional greenhouses developed to the east of the original structure.

Table 2.3 Summary of Historical Map Extracts

2.6 Sensitive Land Uses

The site was recorded to be within a surface water Nitrate Vulnerable Zone (NVZ). A NVZ is an agricultural land conservation designation for areas of land that drain into nitrate polluted waters, or waters which could become polluted by nitrates.

2.7 Environmental Data

Searches of other various environmental databases were made as part of the desk study, including air pollution control sites, Part IIA contaminated land, Integrated Pollution Control (IPC) and Integrated Pollution Prevention and Control (IPPC) site, registered radioactive substances, COMAH sites, explosives sites, Notification of Installations Handling Hazardous Substances (NIHHS) sites, planning permissions for sites involving hazardous substances, contemporary trade directories and fuel station registers.

Two Contemporary Trade Directory Entries were recorded within a radius of 250m of the site, details of which are provided in Table 2.4 below.

Name	Location	Classification	Distance from site
G A Recovery	Laurell, Yapton Road, Barnham, Bognor Regis, West Sussex, PO22 0AY	Car Body Repairs (Active)	39m NE
Susie Holmes Consulting Ltd	Bankside, Church Lane, Barnham, Bognor Regis, West Sussex, PO22 0DG	Horticultural Equipment Maintenance & Repair (Active)	178m NW

Table 2.4 Summary of Contemporary Trade Directory Entries

2.8 Geotechnical Data

The site was recorded as not being in an area affected by a coal mining or non-coal mining. British Geological Survey (BGS) geological hazard assessments for the site are summarised in Table 2.5.

Hazard	Designation
Collapsible ground	Low Hazard
Compressible Ground	No Hazard
Ground dissolution	No Hazard
Landslide	Very Low Hazard

Running sand	Low Hazard
Swelling clay	Low Hazard

Table 2.5 Summary of BGS Geological Hazards

2.9 Ground Gases

A search of historic and authorised landfill sites was undertaken as part of the desk study. Such sites may form an artificial source of ground gases, such as carbon dioxide and methane, where wastes are buried or disposed of to landfill.

One historic landfill was identified within a 250m radius of the site boundary, details of which are provided in Table 2.6.

Name	Location	Specified Waste	Distance from site
Disused Canal at Barnham	Barnham, West Sussex	Deposited Waste Included Inert Waste	241m S

Table 2.6 Summary of Historical Landfill Sites

2.10 Radon

Reference has been made to the Envirocheck data report. The report indicated that the site lies in an intermediate probability radon area where between 1% and 3% of homes are above the action level. However, no radon protection measures are deemed necessary in the construction of new dwellings.

2.11 Geochemistry

Data obtained as part of the Envirocheck Report provides details on the estimated soil chemistry for natural soils in the vicinity of the site. The estimated quality of natural soils beneath the subject site is presented in Table 2.7.

Determinant	Concentration (mg/kg)	In Excess of SGV/GAC/C4SL*?
Arsenic	<15	No
Cadmium	<1.8	No
Chromium	60-90	No
Lead	<150	No
Nickel	15-30	No

NOTE: *Comparative SGV/GAC/C4SL concentrations are for a residential end use with plant uptake

Table 2.7 Summary of Site Geochemistry

2.12 Previous Ground Investigations

Geo-Environmental were not aware of any previous ground investigations undertaken on site.

2.13 Generic Contamination

There were no historical uses of the site other than as field, residential property in the north-eastern corner and a plant nursery. These land uses are not covered by the National House Building Council (NHBC), Environment Agency (EA) and Chartered Institute of Environmental Health (CIEH) publication 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (2008), which provides a summary of industrial profiles (1995-1996) published by the former Department of the Environment (DoE) (now part of the Department for Environment, Food and Rural Affairs (DEFRA)).

The former site use as a plant nursery is not associated with any form of generic contamination



however, there are contaminants associated with nurseries including Total Petroleum Hydrocarbons (TPH), Poly-Aromatic Hydrocarbons (PAH), heavy metals and pesticides including DDT.

No evidence of above ground storage tanks was identified during the site walkover and whilst two tanks were indicated on the historic maps, these could have been for water storage.

In addition, the desk study identified an historic landfill c. 241m to the south of the site boundary, which may have resulted in the potential for ground gas generation.

Furthermore, the demolition rubble produced as a result of clearing the site was noted to be spread across the site and mixed into the shallow soils which may have resulted in contamination of the natural soils on site.

3.0 PRELIMINARY RISK ASSESSMENT

Based on the findings of the desk study, the following sections summarise the anticipated geotechnical and environmental factors likely to impact the site.

3.1 Geotechnical Risk Assessment

The following factors that might impact the geotechnical condition of the site were identified as part of the desk study:

- The possible presence of Made Ground which if encountered may affect the foundation design and construction.
- The presence of laterally and vertically variable strata and the impact these could have on construction.
- Consideration of the volume change potential of cohesive horizons of the River Terrace Deposits and the effect this could have on foundations.
- The viability of soakaways as means of disposal of storm water run-off.
- The presence of trees on the site, which may have a significant impact on foundation design and construction if/where shrinkable soils are present.
- The presence of shallow groundwater and/or perched groundwater beneath the site.

3.2 Environmental Conceptual Model

3.2.1 Methodology

A Preliminary Risk Assessment (PRA) and Conceptual Site Model (CSM) have been prepared in accordance with CLR11 based on information obtained as part of the desk study. Possible risks associated with potential sources of contamination and sensitive receptors identified have been assessed following a source-pathway-receptor (SPR) approach in accordance with current UK protocols.

A risk may only exist where a plausible SPR linkage is present, and where the quantity or concentration of a contaminant is sufficient so as to pose harm. Under the statutory definition, "Contamination" may only strictly exist where contaminants pose a risk of harm to a receptor. Risk may be defined as a function of the likelihood and severity of any adverse effects arising from contamination. The risk classification has been assessed in accordance with CIRIA C552 (Rudland *et al.*, 2001). A summary of how the risks are derived and their definitions are presented in Table 3.1 and 3.2 below:

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very high risk	High risk	Moderate risk	Moderate/low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low Likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

Table 3.1 Risk Ratings Matrix

Risk Rating	Definitions
Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not already undertaken) and remediation are likely to be required.
High risk	Harm is likely to arise to a designated receptor from an identified hazard Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not already undertaken) is required and remediation works may be necessary in the short term and are likely over the longer term.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.
Moderate to low risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is unlikely that any such harm would be severe, or if any harm were to occur it is probable that the harm would be relatively mild.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Table 3.2 Risk Ratings Definition

3.2.2 Summary of Plausible Sources

Possible sources of contamination identified or discounted as part of the desk study are summarised in Table 3.3.

Source	Description	Comments
Shallow soils/Made	General background chemical quality of	Possible elevated metals,

Ground	the near surface soils. Historical use of the site as a plant nursery. Demolition rubble mixed into the shallow soils in parts of the site.	organic and inorganic contaminants. Possible residual presence of pesticides within shallow soils.
Ground Gases	Hazardous ground gases could be present associated with deposited Made Ground and off-site historic landfill.	Possible migration of hazardous ground gas, e.g. carbon dioxide, methane through permeable strata.

Table 3.3 Possible Sources of Contamination**3.2.3 Summary of Plausible Pathways**

The plausible pathways are summarised below:

- direct contact (soil, dust and vegetable ingestion, dermal contact and dust inhalation);
- soil gas inhalation;
- vertical and lateral migration including leaching;
- root uptake; and
- chemical attack of infrastructure (including water supply pipes) and building foundations.

3.2.4 Summary of Plausible Receptors

Potential receptors associated with the site and its development, identified or otherwise discounted are summarised in Table 3.4.

Receptor	Description	Comments
End Users	Occupants of the proposed residential development	The development will have private gardens and areas of soft landscaping.
Adjacent Land Users	Sensitive land uses identified within the immediate vicinity	Adjacent land uses are commensurate with the proposed development i.e. residential.
Soft Landscaping	Areas of planting including lawns, shrubs, trees, etc.	Private gardens, as well as soft landscaped areas are proposed.
Water Supply Pipes	Plastics for potable water supply pipes may be laid in contact with contaminated soils	Significant depths of Made Ground are not anticipated. Chemical quality of near surface soils may impact material selection.
Buildings & Infrastructure	Buried concrete for foundations etc. may be laid in contact with contaminated/aggressive soils	Significant depths of Made Ground are not anticipated. Chemical quality of near surface soils may impact on the proposed building materials utilised.
Groundwater	Controlled Waters contained within the aquifer(s) beneath the site	The site lies upon a Secondary 'A' aquifer.
Surface Water	Controlled Waters within lakes, rivers, ponds, etc., or coastal waters	The nearest surface water body is a drainage ditch located within the site boundary.

Table 3.4 Possible Receptors of Contamination

Site workers involved in the preparation and construction of the development have not been considered in this assessment as the principal contractor is duty bound under the current CDM Regulations to undertake their own risk assessments with respect to their employees.



Whilst the above sources and receptors have been identified, Table 3.5 summarises the identified plausible pollution linkages and a qualitative assessment of the risks based on the desk study research:



Ground Investigation Report

Potential Source/Media	Potential Receptors	Possible Pathways	Probability	Consequence	Risk & Justification
Contaminants in Made Ground/Shallow Soils	End Users	Direct contact	Likely	Mild	Moderate to Low Future residents are likely to come into contact with soils via direct contact in the private garden or home. The consequence is likely to be mild
	Adjacent Land Users	Direct contact	Likely	Mild	Moderate to Low A public footpath and a cycleway are to connect the site with adjacent plots, hence adjacent site users are likely to come into contact with soils in areas of soft landscaping. However, the consequence is likely to be mild
	Soft Landscaping	Root uptake	Low	Minor	Very Low Soft landscaping is included within the proposed development. However, no evidence of harm to existing vegetation was observed on site
	Water Supply Pipes	Direct contact	Likely	Minor	Low Water supply pipes are likely to come into contact with impacted soils depending upon depth of installation and extent of soil impact.
	Buildings and Infrastructure	Direct contact	Likely	Minor	Low Foundations and utilities will be placed within soils, however the consequence is anticipated to be minor.
	Groundwater	Vertical migration	Likely	Minor	Low The site is located over a Secondary 'A' aquifer underlain by Unproductive stratum. Groundwater is likely to be shallow. The risk of downward migration is considered likely however the presence of significant mobile contamination on site is considered to be low.
	Surface Water	Lateral migration	Low	Minor	Very Low A series of drainage ditches are located on site. Some elevated concentrations of contaminants may be anticipated on site due to its historic use as a nursery. However, the majority of the ditches are to be infilled prior to the proposed development.



Ground Investigation Report

Potential Source/Media	Potential Receptors	Possible Pathways	Probability	Consequence	Risk & Justification
Ground Gases & Vapours	End Users	Inhalation	Low	Medium	Moderate to Low There is the potential for gas generation in areas of Made Ground and the off-site infilled canal. Ingress of hazardous ground gas through floor slabs, service penetrations, wall cavities and the like could occur and could result in harm to human health. Incorporation of gas protection measures could mitigate the risk of harm, if a pollutant linkage is confirmed by monitoring.
	Adjacent Land Users	Inhalation	Unlikely	Minor	Very Low Proposed services do not create any migration pathways to adjacent land, therefore it is unlikely that hazardous gases generated on site could pose risk to the adjacent land users.
	Buildings and Infrastructure	Gas accumulation and potential explosion of flammable gases	Low	Medium	Moderate to Low Ingress and accumulation of gas could occur within buildings (without protection measures) and ignition could result in explosion and significant structural damage. However, due to the distance of the site from the historic landfill, high concentrations of hazardous gas are not expected on site.

Table 3.5 Plausible Pollution Linkages

3.3 Scope of Works

In summary, the following scope of works for the intrusive investigation was agreed with the Client.

- Excavation of trial pits, using a mechanical excavator, at 7No. locations across the site with sampling, in-situ testing and logging of recovered soils. The positions were located to provide a general coverage of the site.
- The construction of window sampler boreholes at 6No. locations to provisional depths of 4m bgl with sampling, in-situ testing and logging of recovered soils. The window sample boreholes were positioned to provide a general coverage of the site.
- Super Heavy Dynamic Probing adjacent to 4No. window sampler boreholes to aid the geotechnical assessment.
- Installation of combined ground gas and groundwater monitoring wells within 3No. window sampler boreholes to provide general coverage of the site.
- Return visits on six occasions at fortnightly intervals to record ground gas data and ground gas concentrations and groundwater depths within each monitoring well.
- Trial pit soakage tests in general accordance with BRE Digest 365 within selected trial pits.
- Geotechnical laboratory testing on soil samples recovered from the exploratory holes to support the geotechnical assessment.
- Geochemical laboratory testing on near surface soils for a suite of commonly occurring brownfield contaminants with analysis of selected soil samples for Waste Acceptance Criteria and pesticides.
- Provision of an Interpretative Geotechnical Report detailing the ground and groundwater conditions encountered during the intrusive investigation, laboratory testing results, geotechnical assessment and contamination assessment.

3.4 Investigation Strategy

The positioning of exploratory holes was determined to provide general coverage of the site. Table 3.6 sets out the general strategy adopted for the environmental assessment and Table 3.7 sets out the geotechnical investigation strategy adopted.

Environmental Area of Concern	Investigation	Positions
General ground conditions	Boreholes and trial pits located across the site, coupled with sampling and laboratory analysis.	All
Ground gas regime	Installation of monitoring wells and subsequent 'spot' monitoring.	WS1, WS4 and WS7

Table 3.6 Summary of Environmental Investigation Strategy

Soil samples were collected and placed into amber jars, plastic tubs and cool boxes on site for transit to the office, where they were stored under chilled conditions (<4°C) prior to final transportation in cool boxes to the laboratory by their in-house courier. Both the geotechnical and contamination testing were undertaken by UKAS accredited laboratories. Contamination testing of soil samples was also undertaken in accordance with accredited MCERTs protocols. Samples were stored in temperature controlled conditions from sampling until receipt at the laboratory from which time sample preparation and storage was determined by testing requirements and in line with the laboratory's protocols.

Geotechnical Factor	Investigation	Positions
Competent strata and variability in ground conditions	Exploratory holes located across the site, sampling and laboratory analysis.	All
Shrinkable soils	Exploratory holes located across the site, sampling and laboratory analysis.	All
Groundwater	Installation of monitoring wells.	WS1, WS4 and WS7
Drainage	Trial pit soakage tests.	TP6 and TP7

Table 3.7 Summary of the Geotechnical Investigation Strategy

4.0 ENCOUNTERED CONDITIONS

A factual record of the conditions encountered during the physical investigation of the site is presented in the following sections.

For further details of the ground conditions, reference should be made to the exploratory hole logs presented in Appendix B, the geotechnical testing results in Appendix C, geochemical testing results and statistical assessment in Appendix D and ground gas assessment in Appendix E.

The physical ground investigation works were undertaken on 22nd of June 2015.

Unless stated otherwise, all depths are reported as metres below ground level (m bgl).

4.1 Soils

The ground conditions encountered were broadly consistent with those anticipated from the desk study, i.e. with a succession of Topsoil and/or Made Ground over River Terrace Deposits. The underlying London Clay Formation was not encountered. In addition, in several areas across the site the Topsoil appeared to have been disturbed and re-worked such that extraneous fragments such as brick, concrete, reinforcing bars, nails and cast iron fragments were encountered. These soils were logged as Made Ground, although were considered to be derived primarily through natural processes prior to disturbance rather than through the importation or placement of soils and/or fill materials in an *ad hoc* manner on the site. The ground conditions are summarised in Table 4.1.

Top (m bgl)	Base (m bgl)	Description
0.00	0.25 – 0.30	TOPSOIL: Light brown, brown and black clayey silt, slightly silty sandy clay with frequent roots and rare flint gravel.
0.00	0.25 – 0.95	MADE GROUND: Brown silty sandy clay, clayey silt with occasional carbonaceous inclusions, flint gravel and fragments of brick, concrete, cast iron, nails, cloth and glass.
0.25 – 0.95	0.85 – 2.00	RIVER TERRACE DEPOSITS (COHESIVE): Soft to stiff orangish brown, light greyish, brown, reddish brown CLAY, sandy clay, slightly sandy clay, sandy silty clay, very sandy, slightly clayey silt with occasional gravel and rare ferruginous and carbonaceous inclusions. Gravel is fine to medium, sub-angular to sub-rounded flint.
0.85 - 2.00	2.60 - 3.00	RIVER TERRACE DEPOSITS (GRANULAR): Loose becoming medium dense brown silty fine to medium SAND

Table 4.1 Summary of Ground Conditions



Occasional roots and rootlets were identified within the clayey soils of the River Terrace Deposits as follows:

- TP1 0.25 -1.0m rare roots up to 1mm diameter.
- TP3 0.30-1.1m occasional roots up to 1mm diameter.
- TP4 0.45- 0.7m frequent roots up to 2mm diameter.
- TP5 0.30-0.95m occasional roots up to 1mm diameter.
- WS2 GL -0.40 occasional roots up to 1mm diameter.
- WS7 GL – 0.60m occasional roots up to 2mm diameter.

Whilst no organoleptic evidence of contamination was identified during the logging/description process, the recovered soils were sampled for laboratory analysis to clarify the PRA and site observations.

For more detailed descriptions at specific locations, reference should be made to the exploratory hole logs presented in Appendix B.

4.2 Groundwater

Groundwater was encountered within all of the trial pits and window sampler boreholes during the intrusive investigation. The groundwater strikes within the intrusive positions are summarised in Table 4.2. It should be noted, that the records for window sampler boreholes are representative of short term post-drilling conditions rather than the groundwater ingress depth beneath the site.

Location	Water depth (m bgl)
WS1	2.00
WS2	2.40
WS4	2.00
WS5	2.00
WS6	2.00
WS7	2.00
TP1	2.85
TP2	2.90
TP3	2.95
TP4	2.40
TP5	2.85
TP6	2.70
TP7	2.65

Table 4.2 Summary of Groundwater Records within Trial Pits

Subsequent groundwater monitoring undertaken within standpipes installed during the intrusive investigation did not record any groundwater. However, this is likely to be due to a prolonged dry period at the time of the monitoring. It is anticipated that groundwater could be present at relatively shallow depth during winter months or during prolonged wet periods.

It should be noted that changes in groundwater and perched water levels do occur for a number of reasons including seasonal effects and variations in drainage. Such fluctuations may only be recorded by the measurement of the groundwater level within a series of standpipes or piezometers installed within appropriate response zones.



4.3 Obstructions

No obstructions were encountered on site during the intrusive works. However, obstructions elsewhere on site should not be discounted.

4.4 Ground Gas

Dual purpose gas and water monitoring standpipes were installed within three of the window sampler boreholes across the site to provide general coverage.

The wells were spot monitored for methane, carbon dioxide, oxygen and flow rate on six occasions between June and August 2015.

During the monitoring the maximum methane concentration detected was 0.1% v/v, whilst carbon dioxide and oxygen were present in the range 0.0-4.9% v/v and 10.5-21.3% v/v, respectively. Borehole flows varied from 0.0ℓ/hr to 0.1ℓ/hr. Atmospheric pressure ranged from 1009mb to 1022mb.

For further details, reference should be made to the ground gas assessment sheet in Appendix E.

4.5 Chemical Analysis

In order to assess the general chemical quality of the strata encountered, samples of soils recovered from the exploratory holes were submitted for analysis for a range of potential contaminants selected on the basis of the findings of the desk study and supported by CLR publication CLR8 and Environment Agency R&D66 publication.

The testing rationale included sampling and analysis to provide a general coverage from the exploratory hole. Testing was undertaken for a broad range of commonly occurring contaminants including metals, metalloids, inorganic compounds, speciated TPH, PAH and asbestos.

Furthermore, targeted analysis was also undertaken on five soil samples for pesticides, a potential contaminant associated with the former land use.

Due to low levels of groundwater and lack of water within the standpipes during the post-fieldwork ground gas and groundwater monitoring, it was not possible to obtain water samples for laboratory analysis.

4.6 Geotechnical Testing

Soakage tests were undertaken in Trial Pits TP6 and TP7. The location of the pits was restricted by access constraints on site. Despite, the presence of sandy horizons in River Terrace Deposits, the fall in water level within the pits was negligible and further affected by the collapse of sands in each pit.

Geotechnical laboratory tests were undertaken on selected samples encountered within the exploratory holes. The results are summarised in Table 4.3 below and test results are presented in Appendix C.



Parameter	Stratum	
	River Terrace Deposits (Cohesive)	River Terrace Deposits (Granular)
Moisture Content (%)	12 – 24	-
Liquid Limit (%)	28 – 46	-
Plastic Limit (%)	14 – 22	-
Plasticity Index (%)	14 – 25	-
Modified Plasticity Index (%)	9 – 25	-
pH	7.82 – 7.83	7.03 – 8.12
Water soluble sulphate (g/l)	0.30 – 0.34	0.36

NOTE: Modified plasticity index is defined in NHBC Standards Chapter 4.2

Table 4.3 Summary of Geotechnical Laboratory Test Results

Grading analyses undertaken on samples of the sandy horizons of the River Terrace Deposits ranged from silty SAND, clayey SAND, clayey gravelly SAND to slightly clayey silty SAND.

The Modified Plasticity Indices showed the more cohesive samples of the River Terrace Deposits to be of Low to Medium Volume Change Potential as defined in NHBC guidance.

Super heavy dynamic probing was undertaken at four locations adjacent to window sampler boreholes, DP1-DP2 and DP6-DP7. The purpose of the probing was to augment other investigation data in determining the strength of the underlying soils. Probe results are presented in Appendix B and have been incorporated within the geotechnical assessment presented in Section 5 of this report.

5.0 ENGINEERING CONSIDERATIONS

Subsequent to intrusive investigation of the site and receipt of the laboratory test results, the following geotechnical assessments have been made.

5.1 Foundations

On the basis of the ground conditions encountered, it is considered that conventional foundations could be used for the proposed development, with strip or trench fill foundations extending through any Made Ground, disturbed, reworked, desiccated ground or root zones and terminating within the River Terrace Deposits.

Atterberg Limit tests in conjunction with the field observations indicated that the River Terrace Deposits should be treated '*en masse*' as being of a medium volume change potential as defined by the NHBC Standards Chapter 4.2. Therefore, a minimum founding depth of 0.90m is applicable.

However, due to the presence of horizons of soft/low strength clays at several locations and presence of trees on site it is considered that foundations should be taken down through the cohesive soils of the River Terrace Deposits and bear wholly into or on the underlying sands of the River Terrace Deposits. During the intrusive investigation the top of the granular soils on site was recorded between 0.85m bgl and 2.00m bgl

It is possible that groundwater ingress may occur during excavation for deeper foundations, especially if construction takes place during winter months or prolonged wet periods. It is recommended that foundation excavations be concreted or blinded as soon after excavation as possible. Where concreting could take place the following day it is recommended that excavations are not taken to full depth overnight and that the final 0.5m of cover is only removed immediately prior to concreting.

Void former or compressible media should be included where foundations exceed 1.5m bgl, i.e. in line with NHBC guidance.

Where the ground and/or site conditions are such that foundations in excess of 2.5m depth would be required, it is considered that options include the use of engineer designed deep strip, as defined in NHBC Standards, or piled foundations. The latter of these options would be recommended for greater control and reduced risk during construction.

Location specific foundations may need to be considered where the existing drainage ditches are to be removed.

5.2 Floor Slabs

Suspended floor slabs are recommended for this development due to the presence of Made Ground to depths in excess of 600mm bgl and shrinkable soils at shallow depth in some areas.

5.3 Excavations

Both shallow and deeper excavations within the cohesive horizons of the River Terrace Deposits should remain relatively stable in the short to medium term, assuming the absence of water within the excavations. However, the clays will soften rapidly when in contact with water excavations would be anticipated to become unstable in the short term.

Both shallow and deeper excavations within the granular horizons of River Terrace Deposits are unlikely to remain stable. Any excavations where water inflows occur will become highly unstable.



In the event that excavations become unstable, the sides should either be shuttered or excavated to form vertical sides in order to avoid potential adverse heave on foundations at a later date.

It is recommended that personnel should not be permitted to enter any unsupported excavation, irrespective of depth. In addition, ground works should be designed in such a manner as to avoid man entry into any excavations.

5.4 Sub-Surface Concrete

The results of the water soluble sulphate and pH analyses indicate that buried concrete should be designed in accordance with Class DS-1 of BRE Special Digest 1, with an ACEC class of AC-1. The advice of this publication should be taken for the design and specification of all sub surface concrete.

5.5 Soakaways

On the basis of the trial pit soakage tests undertaken, as reported in Section 4.5, it is considered unlikely that conventional soakaways would perform satisfactorily on site as the discharge to the ground is too slow for a soakaway to half empty in any given 24hour period. Thus it is recommended that an alternative means of storage and disposal of storm run-off water should be sought for the entire site.

Furthermore, based on local knowledge, the groundwater would be anticipated at shallow depth during winter months and this would impact the ground's ability to drain the storm water run-off.

It might be possible to consider connection of site drainage to the off-site main drainage network. However, this assumes sufficient capacity (presently or through upgrade) and that such a solution would be acceptable to the relevant regulatory authorities. Alternative options would comprise SUDs type solutions whereby peak storm water flows are stored on site with an attenuated discharge either to off-site drainage, or to the ground. Solutions discharging to the ground (not as conventional soakaways) could include porous/permeable paving, aquacell/in-ground storage type solutions, swales and detention basins.

5.6 Pavements

The Transport and Road Research Laboratory Report (LR1132) entitled '*The Structural Design of Bituminous Roads*' (1984) cites an estimated equilibrium suction index of 5% for the sandy clays of the River Terrace Deposits with Plasticity Indices of between 14% and 25% under average construction conditions and a low groundwater table.

In addition, the natural soils present at shallow depth are considered to be frost susceptible for pavement design purposes.

The engineering characteristics of Made Ground are variable and unpredictable and the CBR value of these materials does not predict the overall settlements that may occur. It would be prudent to assume the Made Ground on site to be frost susceptible throughout thus a minimum pavement thickness of 450mm would be appropriate.

Any hard or soft spots in the formation level may induce reflective cracking in the pavement and allowance should be made for removing hard spots that may be present. In addition, an allowance should be made for proof rolling coupled with excavation and replacement of soft spots.

6.0 ENVIRONMENTAL CONSIDERATIONS

A Generic Quantitative Risk Assessment (GQRA) incorporating the results of the desk study and ground investigation was undertaken, the findings of which are presented in the following sections.

Site workers involved in the preparation and construction of the development have not been considered further in this assessment as the Principal Contractor is duty bound under the current CDM Regulations to undertake their own risk assessments with respect to their employees.

6.1 Outline Risk Assessment

Whilst no potential sources other than the Made Ground were identified, due to the former use of the site as a plant nursery it was considered prudent to undertake further assessment of the potential contamination of soils on site. Furthermore, an historic landfill was identified to the south of the site with potential for hazardous gas generation. As such, soil sampling and geochemical testing was incorporated within the scope of works in order to assess and clarify soil contamination. The analytical suite included commonly occurring brownfield contaminants. No specific sources of contamination outside of this test suite group were identified during the site inspection or intrusive investigation works.

Furthermore, six ground gas and groundwater monitoring visits were undertaken in order to assess the site's gas regime.

6.2 Ground Gas vs. End Users

The desk study and preliminary risk assessment identified the Made Ground on site as a potential source. Furthermore, a disused canal located to the south of the site was recorded as a historic landfill. The scope of works agreed with the Client included a period of spot monitoring for ground gas within monitoring wells installed across the site in order to verify the preliminary assessment.

With reference to the ground gas data and assessment presented in Appendix E, the site's gassing regime was considered to be Characteristic Situation 1 (CIRIA/BS) and Green (NHBC Traffic Light scheme). As such it is considered that on the basis of the gas monitoring undertaken on site, no ground gas protection measures are required within the proposed development.

6.3 Soil Contamination vs. End Users

The presence of a possible contaminant does not necessarily imply that a site or area is contaminated or that there is any unacceptable risk to human health. A Preliminary Quantitative Risk Assessment has been undertaken in order to evaluate any unacceptable risks posed to human health with respect to the proposed redevelopment. It should be noted that this assessment is protective of the chronic long-term effects of contaminants, which is also likely to be protective of any possible immediate acute effects.

Site Specific Assessment Criteria (SSAC) have been derived using CLEA v1.06 and augmented by reference to the respective Soil Guideline Values (SGVs), Generic Assessment Criteria (GAC) published (LQM 2009) and GAC published by CL:AIRE (2010). The respective SSAC have been derived based on site specific data for soil pH and Soil Organic Matter (SOM) was estimated from Total Organic Carbon content as reported for each individual sample.

In the case of Lead, the former SGV was withdrawn and no replacement value published. The Category 4 Screening Level (C4SL) for Lead is 200mg/kg and thus, this assessment has assumed this as the sole assessment criterion for Lead in gardens.

The exploratory holes were located to provide general coverage of the site. Analysis was undertaken on a series of soil samples collected from shallow depth from these exploratory holes.

The assumptions made as part of the CLEA V1.06 calculations for a residential end use with plant uptake are presented in Table 6.1. Copies of the CLEA calculations are enclosed in Appendix D.

	Assumptions			Comments
Land Use	Residential with home grown produce			Commensurate with proposed redevelopment.
Receptor	Female (res)			A conservative assumption using the most sensitive possible receptor.
Receptor Age	1 to 6			Critical receptor age from birth to age 6.
Building	Semi-detached house			A conservative assumption of the private residence proposed.
Exposure depth zone	GL to 1m bgl			Default setting for land use.
Soil Type	Silty loam	pH 7.2	SOM 0.9%	Based on an average of the chemical laboratory results.
Exposure Pathways	Oral	Direct soil & dust ingestion; consumption of home grown produce; soil attached to home grown produce		Default setting for land use.
	Dermal	Indoor & outdoor		Default setting for land use.
	Inhalation	Indoor & outdoor dust & vapour		Default setting for land use.
Occupancy	days/year	hours/day (indoors)	hour/day (outdoors)	Default settings for the critical receptor.
	180 - 365	19 - 23	1	

Table 6.1 Assumptions for SSAC Calculation (CLEA v1.06 Software) – Private Gardens

Statistical analysis of the samples within the dataset was undertaken in accordance with guidance contained in the CIEH/CL:AIRE report '*Comparing Soil Contamination Data with a Critical Concentration*' (May 2008). If the contamination status of the soils is considered in a planning context, the null hypothesis tested by the analysis is whether the true mean concentration is equal to or greater than the critical concentration for a given determinant, with the critical concentration being the relevant SSAC or GAC (the soil screening value) for that determinant in the context of the intended end use of the site. If the analysis shows that the true mean concentration is less than the critical concentration the null hypothesis can be rejected. The guidance recommends that for the null hypothesis to be rejected the analysis should show that there is a 95% (or higher) likelihood that the true mean concentration is below the critical concentration. Where this is the case the site is considered to be acceptable for the planned end use without any necessary remedial measures.

The statistical analysis summary sheets are included in Appendix D.

The results of the statistical analysis indicated that the null hypothesis could not be rejected for several of the determinants, as detailed below in Table 6.2.



Determinant	SSAC (mg/kg)	Sample Mean (mg/kg)	Evidence Level (%)
Benz(a)anthracene	3.2	6.3	55
Chrysene	5.9	6.2	90
Benzo(b)fluoranthene	5.5	5.1	93
Benzo(a)pyrene	5	6.3	85
Indeno(123-cd)pyrene	3.1	4.3	78
Dibenz(ah)anthracene	0.76	1.04	60

Table 6.2 Summary of Determinants (for which the null hypothesis could not be rejected)

Outliers were identified within the dataset for determinants with elevated concentrations all of which related to shallow soils (0.2m bgl) at WS6. Although, no visual evidence to suggest a difference in samples was identified, given that a single sample from the entire dataset exceeded the respective SSAC, it is recommended it is treated as a localised contamination. Following the removal of the sample from the dataset, the statistical analysis showed that the null hypothesis could be rejected with >95% confidence for all the remaining samples.

On the basis of the assessment of polyaromatic hydrocarbons in shallow soils, it is considered that further testing and/or remedial action will be required in order to protect end users in garden areas. However, given the poor physical quality of soils in the central portion of the site they should be considered as not suitable for re-use in private gardens or landscaping area and therefore will need to be removed regardless of the PAH contamination. The removal of the impacted soil from gardens should be undertaken in accordance with a remediation method statement and validated, e.g. through inspection and audit testing.

In addition, all samples submitted for asbestos screens were returned with no asbestos fibres identified. Furthermore, no pesticides were detected within the shallow soils on site.

On the basis of the testing undertaken, it is considered that the Topsoil on site would be suitable for re-use in gardens. However, given that large areas of Topsoil in the central portion of the site have been contaminated with demolition rubble and are considered unsuitable for re-use on site, it is recommended that the undisturbed Topsoil should be stripped and placed in a segregated stockpile away from the disturbed soils.

6.4 Soil Contamination vs. Soft Landscaping

British Standard BS3882:2015 *Specification for topsoil and requirements for use* provides assessment criteria for a number of potentially phytotoxic contaminants in terms of new planting.

The results of the chemical analysis for determinants known to pose a potential phytotoxic risk to plant growth are summarised in Table 6.3 together with the respective adopted Generic Assessment Criteria (GAC) for plant growth. The compliance criteria set out in BS3882:2015 are pH dependent and thus the GAC used relate to the pH range measured on samples recovered from the site.

Determinant	Phytotoxicity GAC (mg/kg)	GAC Exceedances
	pH >7	
Zinc	<300	Yes
Copper	<200	No
Nickel	<110	No

Table 6.3 Summary of Plant Phytotoxicity Assessment

Exceedances of the phytotoxicity GAC occurred for zinc. However, with reference to the previous section the exceedances were only recorded within a single sample of Made Ground which was

deemed unsuitable for re-use in the gardens and soft landscaped areas and will require removal. As such, it is considered that no further remedial measures would be required to protect plants from phytotoxic effects.

6.5 Soil Contamination vs. Built Environment

Recommendations with respect to pH and sulphate in relation to buried concrete are made in Section 5.4.

The current guidance on selection of materials for water supply pipes to be laid in contaminated land is contained in UK Water Industry Research's (UKWIR) report reference 10/WM/03/21 (re-issued 2010). However, guidance is not mandatory and there has been concerns raised by various industry technical associations regarding the document and the methodologies proposed. Although there are concerns regarding the document, in lieu of any further guidance in the first instance the results of this investigation have been compared with the proposed thresholds published in UKWIR Table 3.1. The results of the relevant chemical analyses indicate that all results were below the specific thresholds with the exception of some marginally elevated PAHs which indicate that barrier pipe may be necessary. It is therefore recommended that the results of this investigation be presented to the water utility company as soon as reasonably practicable in order to confirm the pipe material.

As a matter of good practice and to maximise the protection to maintenance workers and utilities, it is recommended that clean, granular backfill is used in service runs and that marker tapes are used for all buried services.

6.6 Soil Contamination vs. Adjacent Land Users

Surrounding land uses were identified to comprise residential properties, analogous with the proposed redevelopment of the site. Given that the unsuitable soils found in the central portion of the site will be removed, no significant risks to adjacent land users are considered to exist.

Nonetheless, it is recommended that dust suppression techniques, e.g. damping down exposed soils, are employed during the demolition and construction phases on site in order to minimise the potential for airborne migration of specific hazards and to manage potential nuisance issues for adjacent land users.

6.7 Ground Gas vs. Adjacent Land Users

On the basis of the site's gassing regime being CS1/Green (CIRIA/NHBC), it is considered that no exposure scenarios exist and thus no specific remedial action is warranted in relation to adjacent land users.

6.8 Soil Contamination vs. Groundwater

The site overlies a Secondary 'A' Aquifer (River Terrace Deposits) underlain by Unproductive Strata and is indicated to be outside of any Source Protection Zones.

Groundwater was encountered within the exploratory holes during the intrusive investigation, but was absent from wells during return monitoring visits. The results of the laboratory testing on soils did not identify any specific source of gross or readily mobile, soil based contamination. This was supported by organoleptic evidence during the intrusive investigation.



Therefore, based on the ground and groundwater conditions encountered, together with the results of the desk study and geochemical test results, it is considered that the risk to groundwater or controlled water is negligible.

6.9 Waste Disposal

The Waste Acceptance Criteria (WAC) analysis was undertaken on two samples of the Made Ground and a single sample of Topsoil. The results of the analysis on natural soils fall within the classification for Inert Waste. The results of the analysis undertaken on Made Ground classified the material as Inert Waste (HP2) and 'Stable non-reactive Hazardous' (HP1) due to exceedances of Total TPH. However, it is recommended that the results are presented to the facility receiving waste for exact classification.

Other materials disposed of from site as part of the demolition or development process may require disposal separately. All materials containing dangerous substances e.g. tar or bitumen, asbestos, mercury, hydrocarbons and PCBs are likely to be classified as Hazardous Waste and therefore susceptible to the relevant legislative controls.

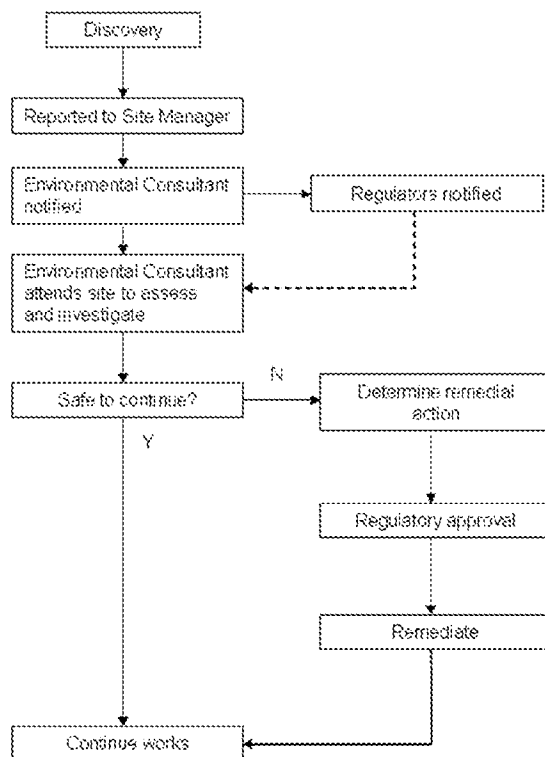
6.10 Discovery Strategy

Whilst an investigation has been undertaken on the site, it remains possible that unexpected soil conditions may be encountered during the process of site demolition, clearance and construction.

Examples may include oily pockets within the soil, pockets of cement boarding or fibrous materials within the soil, black ashy materials, soils exhibiting strong odours, brightly coloured materials and former structures or brickwork.

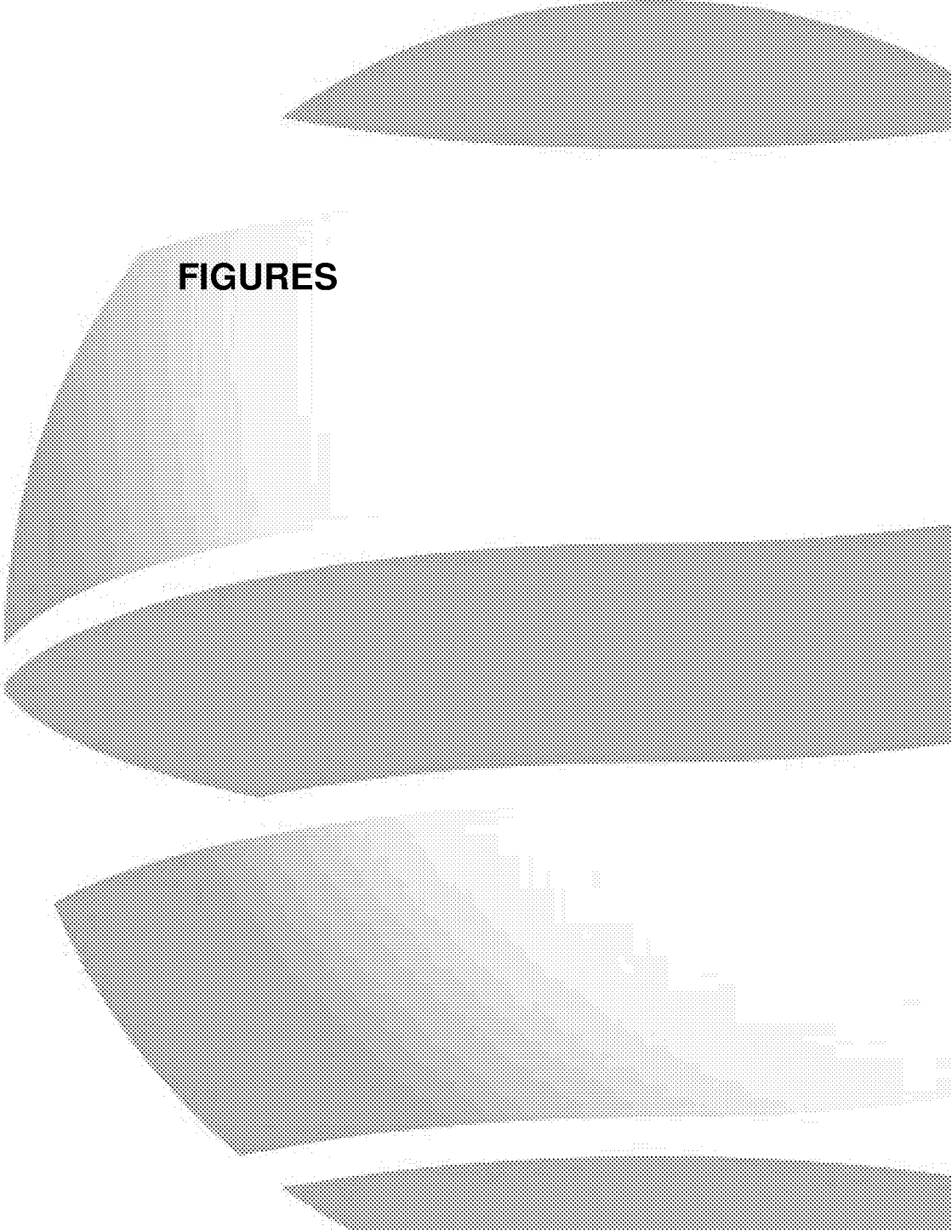
Should previously undiscovered contamination be encountered during construction by the ground workers, this should be reported to the Site Manager immediately in order that any necessary inspection may be made. Records should be kept and samples submitted for analysis where conditions encountered are not as anticipated. The results of any such testing should be sent to the authorities for consultation.

The process is shown below.

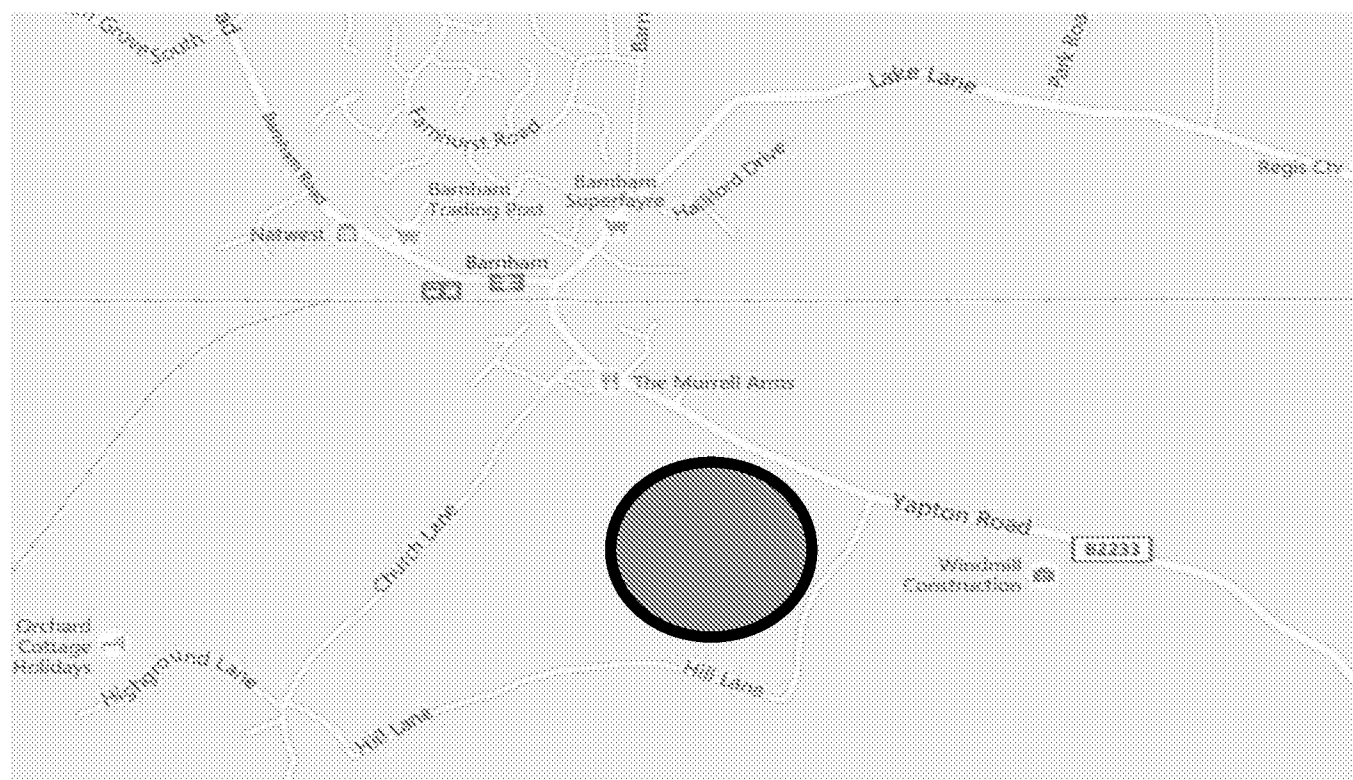
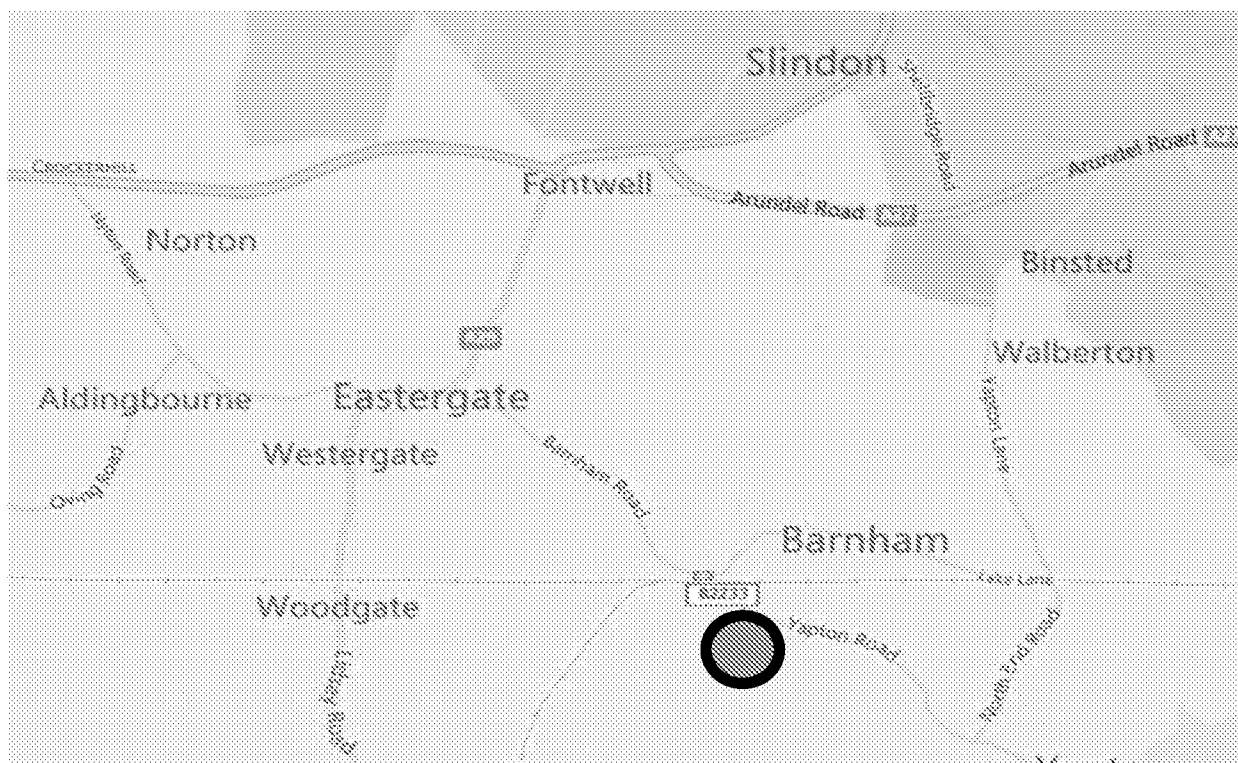


Discovery Strategy Process

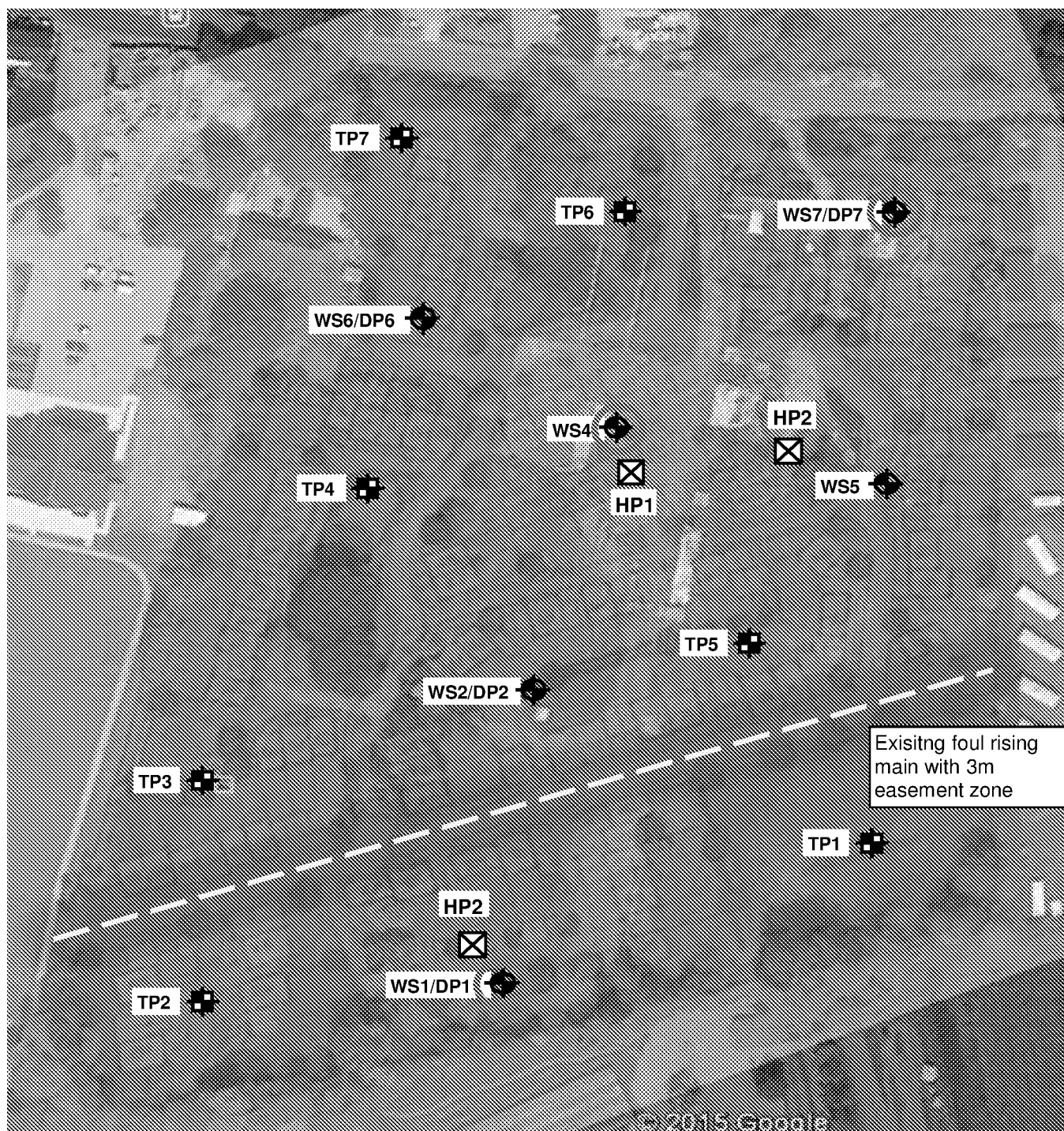
A copy of the discovery strategy should be lodged on site and provisions made to ensure that all workers are made aware of their responsibility to observe, report and act on any potentially suspicious or contaminated materials they may encounter.



FIGURES



Project: Angels Nursery, Yapton Road, Barnham, PO22 0AY		Title Site Location Plan	
Client: Lovell		Geo-Environmental Services Ltd Unit 7, Danworth Farm, Cuckfield Road, Hurstpierpoint, West Sussex, BN6 9GL E: mail@gesl.net T: 01273 832972	
Ref No: GE10423	Revision: FINAL		
Drawn: JO	Date: 12/06/2015		
Figure: 1	Scale: Not To Scale		



Standpipe locations

Project:	Angels Nursery, Barnham			Title:	Site Investigation Plan		
Address:	Yapton Road, Barnham, West Sussex, PO22 0AY			Date:	15/06/2015	Revision:	v1
				Drawn:	JO	 Geo-Environmental	
Grid Ref:		Scale:	Not to Scale	Ref:	GE10423		
Client:	Lovell Partnerships Ltd			Figure:	2		



APPENDIX A

Desk Study Information

Historical Mapping Legends

Ordnance Survey County Series 1:10,560

	Gravel Pit		Sand Pit		Other Pits
	Quarry		Shingle		Orchard
	Osiers		Reeds		Marsh
	Mixed Wood		Deciduous		Brushwood
	Fir		Furze		Rough Pasture
	Arrow denotes flow of water		Trigonometrical Station		
	Site of Antiquities		Bench Mark		
	Pump, Guide Post, Signal Post		Well, Spring, Boundary Post		
	•285 Surface Level				
	Sketched Contour		Instrumental Contour		
	Main Roads		Minor Roads		
	Sunken Road		Raised Road		
	Road over Railway		Railway over River		
	Railway over Road		Level Crossing		
	Road over River or Canal		Road over Stream		
	County Boundary (Geographical)				
	County & Civil Parish Boundary				
	Administrative County & Civil Parish Boundary				
	County Borough Boundary (England)				
	County Borough Boundary (Scotland)				
	Rural District Boundary				
	Civil Parish Boundary				

Ordnance Survey Plan 1:10,000

	Chalk Pit, Clay Pit or Quarry		Gravel Pit
	Sand Pit		Disused Pit or Quarry
	Refuse or Slag Heap		Lake, Loch or Pond
	Dunes		Boulders
	Coniferous Trees		Non-Coniferous Trees
	Orchard		Scrub
	Bracken		Heath
	Marsh		Reeds
	Building		Glasshouse
	Sloping Masonry		Pylon
	Cutting		Embankment
	Road Under		Road Over
	Level Crossing		Foot Bridge
	Standard Gauge Multiple Track		Standard Gauge Single Track
	Siding, Tramway or Mineral Line		Narrow Gauge
	Geographical County		Administrative County, County Borough or County of City
	Municipal Borough, Urban or Rural District, Borough or District Council		Borough, Borough or County Constituency
	Civil Parish		
	BP, BS Boundary Post or Stone		Police Station
	Church		Post Office
	Club House		Public Convenience
	Fire Engine Station		Public House
	Foot Bridge		Signal Box
	Fountain		Spring
	Guide Post		Telephone Call Box
	Mile Post		Telephone Call Post
	Mile Stone		Well

1:10,000 Raster Mapping

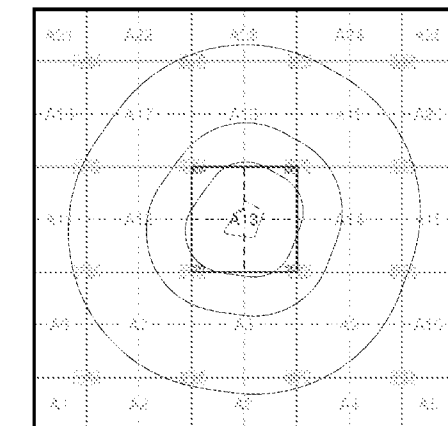
	Gravel Pit		Refuse tip or slag heap
	Rock		Rock (scattered)
	Boulders		Boulders (scattered)
	Shingle		Mud
	Sand		Sand Pit
	Slopes		Top of cliff
	General detail		Underground detail
	Overhead detail		Narrow gauge railway
	Multi-track railway		Single track railway
	County boundary (England only)		Civil, parish or community boundary
	District, Unitary, Metropolitan, London Borough boundary		Constituency boundary
	Area of wooded vegetation		Non-coniferous trees
	Non-coniferous trees (scattered)		Coniferous trees
	Coniferous trees (scattered)		Positioned tree
	Orchard		Coppice or Osiers
	Rough Grassland		Heath
	Scrub		Marsh, Salt Marsh or Reeds
	Water feature		Flow arrows
	Mean high water (springs)		Mean low water (springs)
	Telephone line (where shown)		Electricity transmission line (with poles)
	Bench mark (where shown)		Triangulation station
	Point feature (e.g. Guide Post or Mile Stone)		Pylon, flare stack or lighting tower
	Site of (antiquity)		Glasshouse
	General Building		Important Building



Geo-Environmental Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Sussex	1:10,560	1880	2
Sussex	1:10,560	1899	3
Sussex	1:10,560	1913 - 1914	4
Sussex	1:10,560	1913 - 1914	5
Sussex	1:10,560	1913 - 1914	6
Sussex	1:10,560	1914	7
Sussex	1:10,560	1938 - 1951	8
Historical Aerial Photography	1:10,560	1947 - 1949	9
Sussex	1:10,560	1951	10
Ordnance Survey Plan	1:10,000	1961 - 1962	11
Ordnance Survey Plan	1:10,000	1967	12
Ordnance Survey Plan	1:10,000	1970 - 1979	13
Ordnance Survey Plan	1:10,000	1979	14
Ordnance Survey Plan	1:10,000	1980	15
Ordnance Survey Plan	1:10,000	1992 - 1993	16
10K Raster Mapping	1:10,000	2006	17
VectorMap Local	1:10,000	2015	18

Historical Map - Slice A

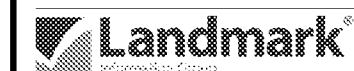


Order Details

Order Number: 70253525_1_1
Customer Ref: GE10423
National Grid Reference: 496260, 104030
Slice: A
Site Area (Ha): 3.5
Search Buffer (m): 1000

Site Details

Angels Nursery, Yapton Road, Barnham, BOGNOR REGIS,
West Sussex, PO22 0AY



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