LAND ADJACENT JOCKEY'S HALL
JOCKEY'S LANE, COMBS

REPORT ON GROUND INVESTIGATION

March 2019
Report No. P0055/R02 Issue 1

Prepared for:

Mr G Gregory

Jockey's Hall
Jockey's Lane
Combs
Stowmarket
Suffolk
IP14 2NH

Prepared by:

Sue Slaven

33 Windmill Close
Great Cornard
Suffolk
CO10 0FL
e-mail: sue.slaven@btinternet.com
Mobile: 0740 360 6234

DOCUMENT INFORMATION AND CONTROL SHEET

Report No. P0055/R02	**Title** **Land adjacent Jockey's Hall, Jockey's Lane, Combs** **Report on Ground Investigation**

Issue History

Issue	Status	Date	Author	Signature
1	Final	20 March 2019	**Prepared by:** Sue Slaven MIEnvSc CEnv SiLC	

DISCLAIMER
This report should be read with the Service Constraints, Report Limitations & Planning Requirements set out in Appendix A.

Land at Jockey's Hall, Jockey's Lane, Combs
Report on Ground Investigation

CONTENTS

FIGURES

APPENDICES

Land at Jockey's Hall, Jockey's Lane, Combs
Report on Ground Investigation

1. INTRODUCTION

1.1 Background Information

1.1.1 Mr Graham Gregory commissioned Sue Slaven to carry out an intrusive ground investigation for the site known as land adjacent Jockey's Hall, Jockey's Lane, Combs. The purpose of the report is to provide information for the site with regards to ground conditions using published data and information obtained from the intrusive investigation.

1.1.2 This report has been devised to generally comply with the relevant principles and requirements of a range of guidance with regards to the investigation of potentially contaminated land, including:

- BS 10175. Investigation of potentially contaminated sites - Code of practice;
- BS 5930. Code of practice for ground investigations;
- Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (Defra, April 2012);
- Defra/Environment Agency (2004). Report CLR11 - Model Procedures for the Management of Land Contamination;
- Environment Agency (2011). Report GPLC1 - Guiding Principles for Land Contamination;
- Environment Agency (2012). Report GP3 - Groundwater protection: Principles and Practice;
- National Planning Policy Framework (HCA, March 2012); and
- Part IIA of the Environmental Protection Act, 1990.

1.1.3 Sue Slaven's service constraints and report limitations are presented in Appendix A and a description of the environmental risk assessment methodology is presented in Appendix B.

1.1.4 In preparation of this report, it is assumed that any information provided by the client or its representatives relating to the commission is accurate, complete and not misleading. However, the accuracy or validity of this information cannot be guaranteed.

1.2 Site Location and General Description

1.2.1 The location of the site is indicated on Figure 1 below and a summary and brief description is presented in Table 1.

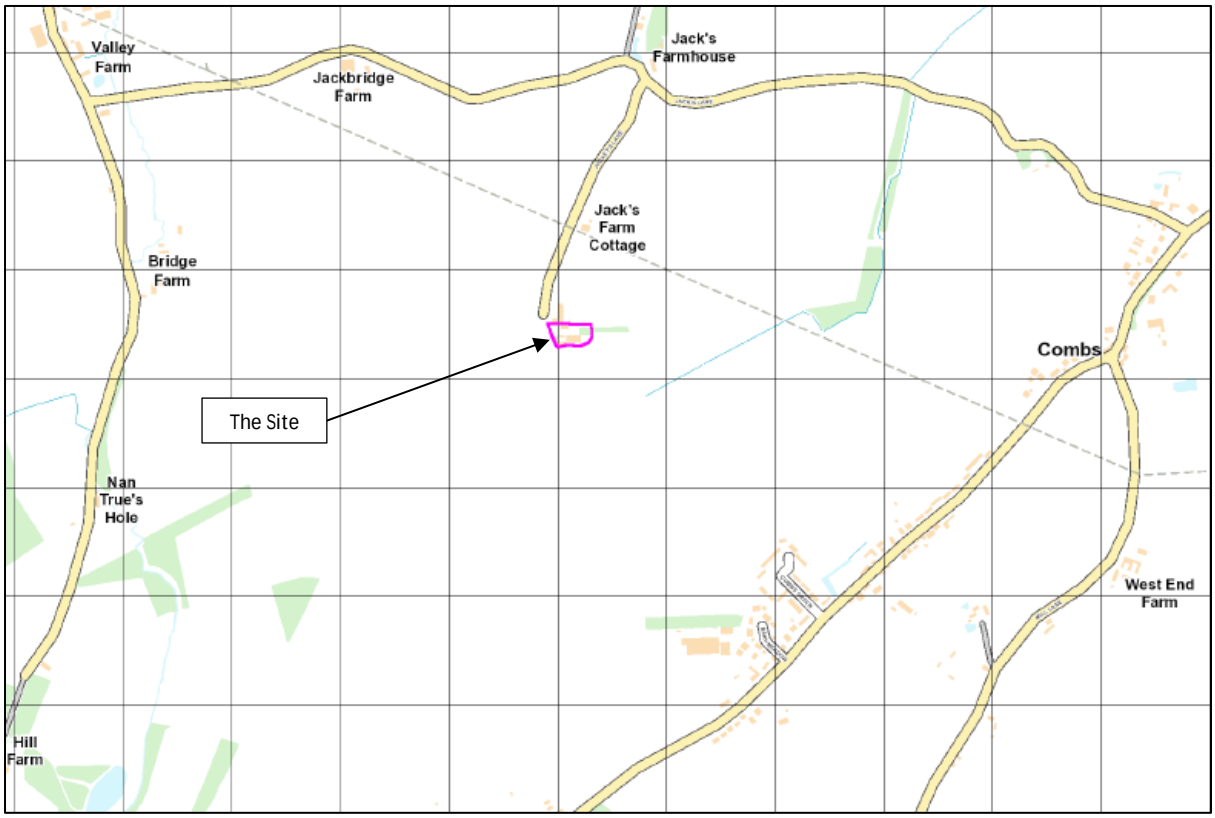


Figure 1 **Site Location (not to scale)**

Table 1 **Summary of Description of the Site and its Environs**

Location	The site is located in a predominantly agricultural area, approximately 1.5km to the east of Combs, 1.9km to the south east of Great Finborough and 3.3km to the south west of the town of Stowmarket.
Grid Reference	602620, 256280
Post Code	IP14 2NH
Site Area	0.28ha approximately
Topography	The site and immediate vicinity are generally level, however, the area is gently undulating.
Description	The site was occupied by several old industrial buildings, primarily of wooden construction and generally arranged on either side of the main access route. The surrounding area was in agricultural use with Jockey's Hall immediately to the north of the site.

1.3 Development Proposals

1.3.1 The site is to be redeveloped comprising the demolition of all existing buildings and clearance of hardstanding and the building of two detached houses with private gardens and garages, together with gravel driveways, as indicated on Figure 2.

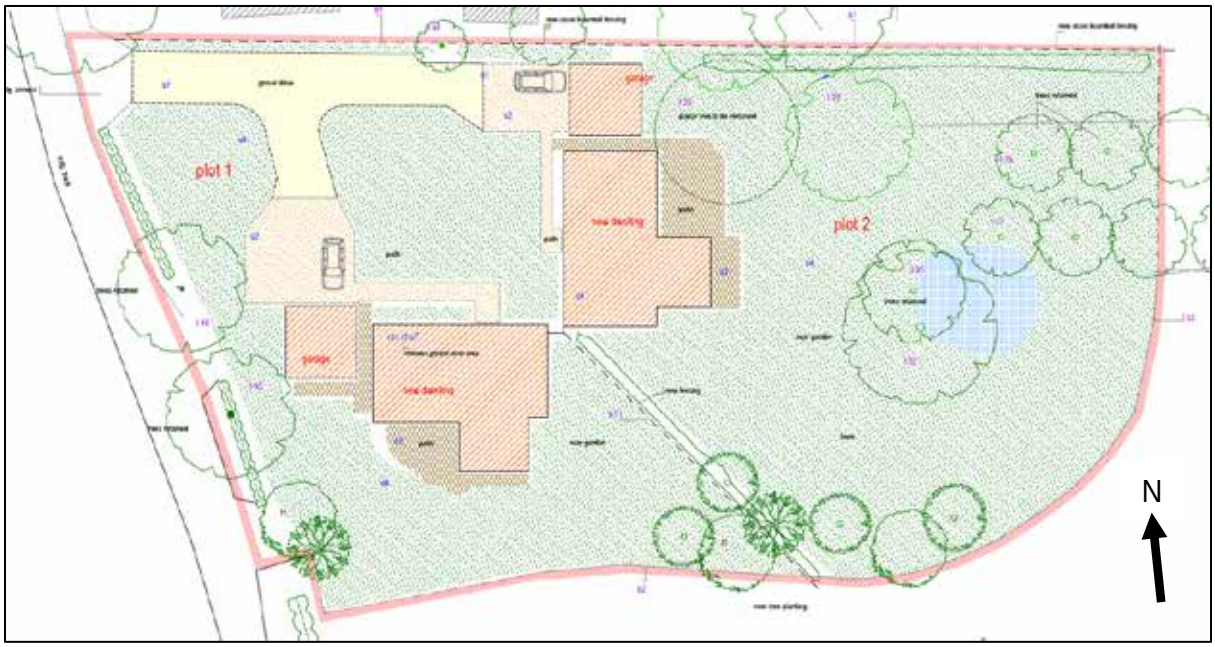


Figure 2 **Proposed Development of the site (not to scale)**

1.3.2 An outline planning application (Ref: DC/18/03923) for the development of the site has been submitted to Mid Suffolk Council in August 2018. However, the application is awaiting a decision.

1.3.3 The findings and conclusions of the risk assessment and recommendations have assumed that the site's future use is to be residential. However, if there is a subsequent change in the land use, the risk assessments and conclusions presented in this report should be reviewed to determine whether they remain applicable.

1.4 Environmental Setting

Geology

1.4.1 A review of the British Geological Survey website indicated that the site is underlain by superficial geology comprising the Lowestoft Formation, which forms an extensive sheet of chalky till. The bedrock geology is the Red Crag Formation.

Hydrogeology

1.4.2 The Lowestoft Formation is classified as a Secondary aquifer and the Red Crag Formation as a Principal aquifer. The site lies within Zone 3 (Total Catchment) of a groundwater Source Protection Zone. There are two boreholes in the vicinity: one at Jockey's Hall 40m to the north west which abstracted from the underlying Chalk and another at Jack's Farm 500m to the north. However, both licences have been revoked.

Hydrology

1.4.3 The nearest surface water is a pond located in the eastern sector of the site. There is a surface watercourse that issues from a location approximately 145m to the south east of the site.

1.5 Previous Site Investigation

1.5.1 It is understood that the site has not been subject to previous investigation with regards to potential ground contamination.

2. FIELDWORK

2.1 Objectives of the Ground Investigation

2.1.1 The principal objective of the ground investigation is to provide information with regards to potentially contaminated land, as follows:

- to confirm the contaminative status of the ground, particularly with regards to on-site sources of contamination;
- to assess the nature and depth of any Anthropogenic Ground; and
- to assess the nature and depth of the natural strata (as far as is practicable).

2.1.2 To achieve the objectives, the specific site investigation and research activities carried out were as follows:

- 1 day's trial pitting involving the excavation of eight exploratory holes across the site to a maximum depth of 2.1m below ground level (bgl);
- Collection of solid samples from the trial pits for contamination testing;
- Description of the ground generally in accordance with BS5930:2015 "Code of Practice for Ground Investigations"; and
- An assessment of the chemical testing data.

2.2 Investigation Strategy

2.2.1 The fieldwork was carried out on 22 February 2019 by the client using a 3-tonne mini-digger at locations predetermined by Sue Slaven. Sue Slaven attended site on 25 February to collect samples and describe the ground encountered.

2.3 Exploratory Holes

2.3.1 A total of eight trial pits were excavated across the site, where possible. The specific locations were determined by access as the buildings remained on-site, as shown on Figure 3.

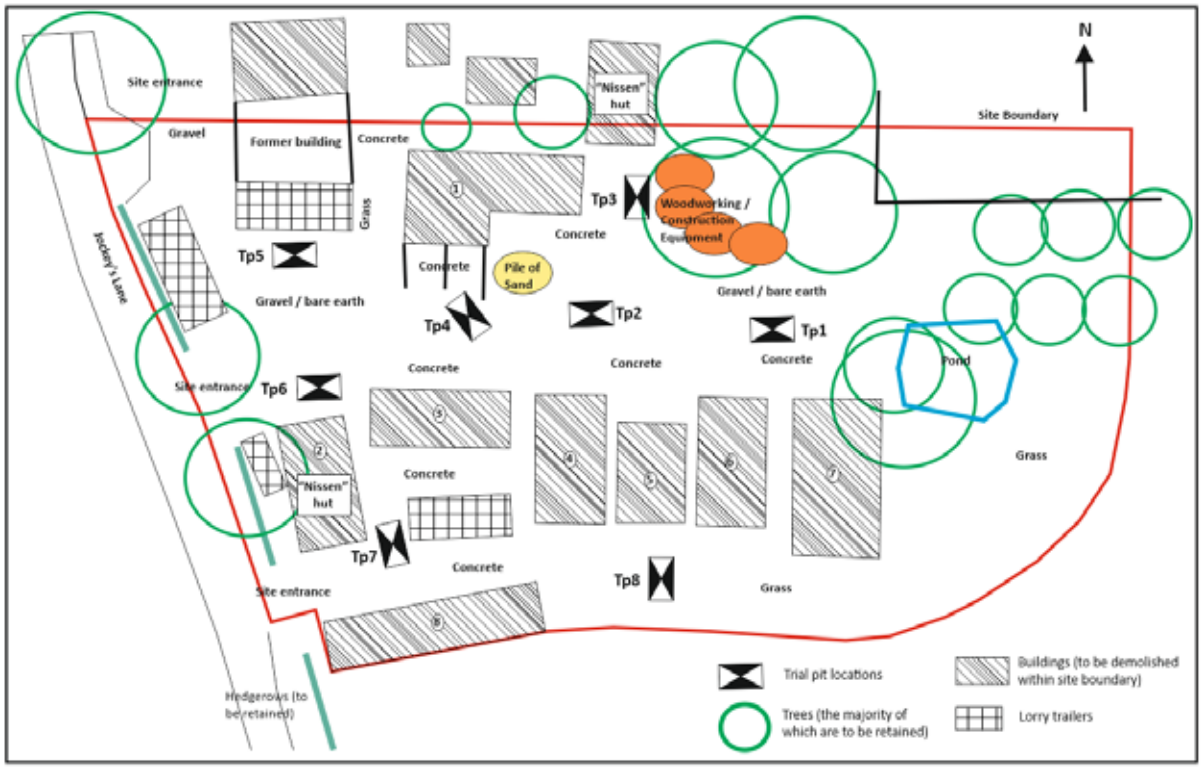


Figure 3 **Exploratory Hole Location Plan (not to scale)**

2.3.2 Ground conditions were described and the logs, together with photographs, are presented in Appendix C. As part of the ground investigation, soil samples were taken to aid the characterisation of the material, as detailed in Section 3.

2.4 Ground Conditions

2.4.1 Ground conditions varied little across the site and generally comprised Made Ground overlying orange brown sandy clay, interpreted as chalky till of the Lowestoft Formation. However, Made Ground was not present at one location, TP8, in the southern sector of the site.

2.4.2 Made Ground was present to a minimum depth of 0.4m bgl and a maximum depth of 0.5m at TP2 and TP6. Generally, the Made Ground consisted of dark brown gravelly sand consisting of road planings, brick and concrete fragments. At one location, TP2, a land drain was encountered at a depth of 0.4m bgl and a black cable within a clay pipe was observed at a depth of 0.4m bgl in TP7.

2.4.3 Beneath the Made Ground at all locations was olive green / brown gravelly sandy clay (chalky till). Gravel was primarily fine to coarse of chalk and occasionally flint. Occasional cobbles of chalk and flint were also encountered. Large pockets or lenses of orange brown medium sand were present in the upper 0.9m of the ground, some of which were saturated with water.

2.4.4 Water was found at the base of four trial pits, however, as the trial pits were excavated two days prior, the source of the water cannot be determined. Five of the trial pits were unstable with side walls collapsing, due to the large pockets of sand present in the chalky till.

2.4.5 No visual or olfactory signs of ground contamination were noted at any of the locations.

3. LABORATORY TESTING

3.1 Sampling Strategy

3.1.1 The selection of samples for laboratory testing and analyses to be carried out were made following observations during the fieldwork. The sample selection rationale was to gain general coverage of the ground across the site. Each sample was contained within a 1kg plastic tub, a 250g amber glass jar and a 100g amber glass jar, labelled and stored in a cool box.

3.1.2 Soil samples were submitted to Concept Life Sciences (CLS) in Braintree, which is UKAS accredited in accordance with BS EN ISO/IEC 17025:2005[1] and MCERTS accredited for soil analysis in accordance with the Environment Agency's scheme. Details of the accreditation and methods of analysis are provided on CLS's test reports included within Appendix D.

3.1.3 Soil samples collected from each trial pit were as follows:

Table 2 Sample Strategy for Testing

Trial Pit No.	Depth	Strata
TP1	0.2m	Made Ground – dark brown gravelly sand of road planings and brick fragments
TP2	0.4m	Made Ground – material above the land drain
TP3	0.3m	The base of the Made Ground
TP4	0.25m	Material beneath the concrete ground cover
TP5	0.5m	Pocket of orange brown fine sand within the chalky till
TP6	0.4m	Made Ground – dark brown gravelly sand of road planings and brick fragments
TP7	0.3m	Made Ground – dark brown clayey sandy soil – above the chalky till
TP8	0.3m	Beneath the topsoil

3.1.4 At least one sample collected from each trial pit was selected for chemical analysis. The testing suite was as follows, which is considered to represent a general range of contaminants analysed to assess the potential risk to human health and the environment:

- Metals: cadmium, chromium, copper, mercury, nickel, selenium, zinc
- Non-metals: arsenic
- Inorganics: total cyanide, water soluble sulphate, sulphide and pH
- Organics: soil organic matter, total organic carbon, total phenols, speciated petroleum hydrocarbons and speciated polycyclic aromatic hydrocarbons (PAHs)

[1] BS EN ISO/IEC 17025:2005. "General requirements for the competence of testing and calibration laboratories".

- Asbestos (presence/absence).

4. TIER 2 RISK ASSESSMENT

4.1 Introduction

4.1.1 The assessment of contamination has been carried out in accordance with the overall guidance presented in CLR 11 – Model Procedures for the Management of Land Contamination (Defra/EA, 2004), other relevant guidance and legislation, using procedures as indicated in the following sections.

4.1.2 Generic quantitative risk assessment (GQRA) is a two-stage process. Firstly, in the Risk Estimation stage, the measured contaminant concentrations are compared to the relevant SGVs/GACs and/or C4SLs/S4ULs, if published. Where there is a suitable dataset, this is undertaken after carrying out statistical analysis to determine the upper confidence limit on the true mean. Otherwise, maximum or specific data points are compared directly. The second stage, Risk Evaluation, comprises an authoritative review of the findings with other pertinent information in cases where C4SLs or GACs are exceeded, in order to consider if exceedance may be acceptable in the particular circumstances.

4.1.3 The aspects of risk from substances in the ground considered below are as follows:

- Human health;
- Pollution of controlled waters;
- Plant life;
- Water supply pipes; and
- Below ground concrete.

Human Health

4.1.4 The overall methodology for assessing the risk to human health from potential contaminants in the ground is presented in Appendix B in accordance with the guidelines as set out in Environment Agency's guidance "Using Soil Guideline Values" (SC050021/SGV Introduction, March 2009) and using the CLEA 1.06 model software. These have been used for a Tier 2 assessment of soil contamination for the protection of human health. The limited number of SGVs that have been published are for a soil organic matter of 6%. For this, the CLEA 1.071 software has been used to derive generic assessment criteria for a soil organic matter content of 1% (as a worst case scenario).

Controlled Waters

4.1.5 The risk posed to controlled waters (groundwater and surface water) from total soil concentrations cannot be directly assessed. The risk is either assessed by comparison of results of leachability tests carried out on soil samples, or from the direct testing of samples

of groundwater/surface water to screening criteria. However, no leachability tests were carried out and no groundwater/surface water samples were collected.

Phytotoxic Risks

4.1.6 Generic assessment of phytotoxicity is by comparison with guideline values presented in the MAFF document "Code of good agricultural practice for the protection of soil" (October 1998). This is in accordance with CLR's reference to Defra notice CLAN 4/04.

Chemical Attack on Buildings

4.1.7 Generic assessment of the chemical attack on building materials has been assessed using guidance in the BRE Special Digest 1: Concrete in Aggressive Ground (2005).

4.2 Assessment for the Protection of Human Health

4.2.1 The GQRA, based on a soil with a Soil Organic Matter of 1%, was carried out in accordance with the methodology set out in Appendix B for assessing soil samples based on a residential end-use. A summary of the chemical testing results is presented in Appendix D, together with the laboratory data. Exceedances of applicable Generic Assessment Criteria (GAC) threshold concentrations are indicated in yellow. A discussion of the results, and in particular, any identified exceedances, is presented below.

Metals

4.2.2 A total of eight soil samples were tested for a range of metals within the analysis suite. Arsenic, cadmium and nickel were identified at elevated concentrations in excess of the relevant GAC at one location, TP1 at a depth of 0.2m bgl. The material at TP1 consisted of road planings that were laid beneath the concrete. It is possible that this location is proposed as a private garden, thus, it is considered that there is a potential risk to human health from these contaminants at this location from pathways such as soil ingestion and inhalation of indoor, together with consumption of home grown vegetables.

PAHs

4.2.3 Polycyclic aromatic hydrocarbons (PAHs) are a wide range of over 200 different compounds normally associated with combustion or processing of hydrocarbons and coal. Elevated levels of PAHs can also be found in tarmac. Sixteen PAHs (usually known as the USEPA 16) comprise the more common individual carcinogenic PAH compounds. However, none of the samples comprised PAHs at concentrations in excess of the relevant GAC.

Hydrocarbons

4.2.4 All eight selected soil samples were tested to determine total and speciated petroleum hydrocarbons (TPH) levels. However, TPH in the fraction C21-C35 aromatic was identified at

an elevated concentration within the same sample from TP1 as elevated concentrations of metals were identified.

Asbestos

4.2.5 Asbestos was searched for within the soil samples and was not detected.

Risks to Human Health (Construction Phase)

4.2.6 During the development works, there may be a risk from soil ingestion, particularly at the location of TP1, to construction workers. A risk assessment should be carried out by the contractor to allow appropriate controls for the mitigation of risk to the health of construction workers and neighbours to be in place. This risk can be controlled to within acceptable limits by:

- Control of dust generation;
- Workers wearing suitable personal protective equipment (PPE), including face masks;
- Having adequate site hygiene facilities allowing staff to keep a good level of personal hygiene;
- All groundworkers should be trained in asbestos awareness and should be aware of this possibly being encountered during excavations. The earthworks contractor should have a contingency plan in place before any works commence in case the presence of asbestos is suspected in groundworks;
- Only permitting smoking or eating on-site in appropriate pre-designated areas.

4.3 Risk to Plant Life

4.3.1 The concentrations of the phytotoxic metals, copper, chromium, nickel and zinc, have the potential to be harmful to plants. However, as indicated in Table 3, these are not present at concentrations that could potential harm plant health. Thus, it is considered that there is no risk to plant health.

Table 3 Phytotoxic elements when compared with MAFF guidance

Determinand	No. of Samples	Trigger Value* (mg/kg)	Range of Concentration (mg/kg)	Exceeds Tier 1 Screening (Y/N)
Copper	8	135	12 – 75	N
Chromium	8	400	17 – 72	N
Nickel	8	110	22 – 71	N
Zinc	8	300	38 – 160	N
*Trigger value from MAFF "Code of good agricultural practice for the protection of soil" October 1998 for a pH of 7. (pH at the site averages 8.)				

4.4 Assessment for the Protection of Controlled Waters

4.4.1 The geology at the site comprises the chalky till of the Lowestoft Formation, overlying the Red Crag Formation, which are classified as a Secondary aquifer and a Principal aquifer respectively. Arsenic, cadmium, nickel and TPH C21-C35 aromatic were identified at one location at concentrations that could present harm to human health. However, with regards to presenting a potential risk to groundwater, this is considered to be negligible as ground conditions at the location comprised stiff gravelly sandy clay. Perched groundwater was encountered within sand pockets of the chalky till, however, these were small and unlikely to affect groundwater at a deeper depth, i.e. the Red Crag.

4.5 Water Supply Pipe Material

4.5.1 Plastic pipe materials are potentially vulnerable to attack from elevated levels of hydrocarbons, which can potentially lead to contamination of potable water supplies. Water supply companies are also required to assess the risk to their workers from contaminants in the ground. However, based on the chemical test results, hydrocarbons were not present in significant quantities to affect pipe material.

4.6 Chemical Attack on Below Ground Concrete

4.6.1 Below ground concrete structures are potentially at risk in areas of elevated sulphates and low pH. An assessment of the soil data (following the guidance published in BRE Special Digest 1, 2005) show that the maximum concentration of water soluble sulphate at the site was recorded at 0.05g/l and maximum pH was 8. This equates to Design Sulphate Class DS-1 and an ACEC Class of AC-1. Therefore, based on the available data, it is likely that no special precautions are required at the site for the design of concrete in terms of the durability and structural performance.

4.7 Summary of Contaminant Linkage Assessment

4.7.1 The results of the risk assessment indicate that there is a potential risk to human health (future site occupiers and construction workers) from the presence of arsenic, cadmium, nickel and TPH (C21-C35 aromatic) in the ground, at one location, TP1. The principal pathway is soil and/or dust ingestion.

4.7.2 A Conceptual Site Model was presented in the Phase 1 Desk Study, which can be updated based upon the findings of the ground investigation, as presented in Table 4.

Table 4 Updated Conceptual Site Model

Source		Pathway		Critical Receptor	Risk Assessment
Arsenic, cadmium, nickel and TPH within road planings at TP1	®	Soil ingestion; inhalation of dust indoors; consumption of home-grown vegetables	®	Future site occupiers	High – area proposed as private garden.
			®	Construction workers	Low – provided appropriate controls in place during groundworks
	®	Direct contact	®	Buildings and hardstanding	Low – contaminants are not known to have any effect on built structures
			®	Underground services	Low – provided services are placed in "clean" corridors

5. CONCLUSIONS

5.1 Environmental Risk Assessment

5.1.1 A generic quantitative risk assessment (GQRA) has been made based on the contaminant - pathway - receptor model as defined in Part IIA of the Environment Protection Act 1990 and in accordance with BS 10175 "Investigation of potentially contaminated sites - code of practice". An intrusive investigation was carried out in February 2019, which involved the excavation of eight trial pits across the site, the collection and testing of solid samples. Ground conditions generally comprised Made Ground, overlying orange brown gravelly sandy clay (Chalky Till of the Lowestoft Formation). Groundwater was encountered at most locations within sand pockets and unstable conditions, i.e. trial pit sidewall collapse, were experienced.

5.1.2 Solid samples were selected from the Made Ground for analysis of a range of determinands including metals, inorganic and organic substances, and asbestos. Arsenic, cadmium, nickel and TPH (C21-C35 aromatic) were identified at elevated concentrations at one location, TP1 within road planings. The results of the risk assessment indicate that the presence of these contaminants in the ground present a risk to human health (construction workers) through soil and/or dust ingestion, although the risk can be mitigated through appropriate controls (Section 4.2). A risk to future site occupiers is assessed to be high as the area of TP1 is proposed as a private garden.

5.2 Recommendations for Further Works

5.2.1 The following indicative recommendations are made based on the information obtained from the ground investigation carried out, and in the context of redevelopment to a residential end-use with private gardens. Based on the information described above, it is considered that remediation works are likely to be required in order to mitigate the risk to future site users, including construction workers.

5.2.2 In order to reduce potentially unacceptable risks to future site occupiers, the following measures are recommended. It is likely that contaminants are restricted to road planings located beneath the concrete, as no other contaminants were identified within the Made Ground. Thus, it is also likely that these will be removed as part of the groundworks to prepare the site for development. Although a risk to groundwater is considered to be low at this location, perched groundwater was encountered at other locations (within the sand pockets present in the chalky till) and it is recommended that the road planings be removed and disposed of off-site or be re-used on-site beneath permanent structures (subject to the agreement of the Local Authority). This will act as a barrier to rainwater / surface water penetrating the ground and potentially mobilising contaminants into groundwater.

5.2.3 A potential risk to construction workers during groundworks is identified, therefore it should be ensured that works are carried out in a safe manner and all available contaminant information is provided to the Contractor. The Contractor should have regard to current legislation and guidance, which includes the following:

- Health & Safety at Work Action 1974;
- Environment Protection Act 1990;
- All health and safety matters, in particular the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 1988 and guidance from the Health & Safety Executive;
- Construction (Design and Management) Regulations 2015.

5.2.4 For any underground pipes, provision should be made for protection of water services from contaminant ingress, subject to discussion and agreement with the relevant water authority.

5.2.5 All materials for off-site disposal should be removed to an appropriately licensed waste management facility: disposal being carried out in compliance with S.34 of the EPA, "Duty of Care".

5.2.6 It is recommended that the contractor provide evidence to demonstrate that any imported material to be used in proposed garden areas and/or landscaped areas is uncontaminated and suitable for its purpose. Evidence should include its chemical suitability, its source and storage prior to delivery at site, together with a clear chain of custody. It should be noted that Local Authorities will not accept the supplier's certification with regards to imported soils.

5.3 Unforeseen Ground Contamination

5.3.1 There is the potential for areas of unexpected contamination to be encountered upon removal of material that is present on-site. Any significant quantities of asbestos, significant ashy soils, unusual, brightly coloured or significantly oily or odorous material should be considered in this category. If unexpected contamination is discovered during groundworks, the following procedures should be adhered to:

(1) All site works at the location of the suspected contamination will cease.

(2) A suitably trained geoenvironmental specialist should assess the visual and olfactory observations of the ground and the extent of contamination and the Client and the Local Authority should be informed of the discovery.

(3) The suspected contaminated material will be investigated and tested appropriately in accordance with assessed risks. The investigation works will be carried out in the presence of a suitably qualified geoenvironmental engineer. The investigation works shall commence to recover samples for testing and, using visual and olfactory observations of the ground, delineate the area over which contaminated materials are present.

(4) The unexpected contaminated material will either be left in situ or be stockpiled (except if suspected to be asbestos) whilst testing is carried out and suitable assessments completed to determine whether the material can be re-used on site or requires disposal, as appropriate.

(5) Where the material is left in situ awaiting results, it will either be reburied or covered with plastic sheeting.

(6) Where the potentially contaminated material is to be temporarily stockpiled, it will be placed either on a prepared surface of clay, or on 2000-gauge Visqueen sheeting (or other impermeable surface) and covered to prevent dust and odour emissions.

(7) Any areas where unexpected visual or olfactory ground contamination is identified will be surveyed and testing results incorporated into a Verification Report.

(8) A photographic record will be made of relevant observations.

(9) The testing suite will be determined by the independent geoenvironmental specialist based on visual and olfactory observations.

(10) Test results will be compared against current assessment criteria suitable for the future use of the area of the site affected.

(11) The results of the investigation and testing of any suspect unexpected contamination will be used to determine the relevant actions. After consultation with the Local Authority, materials should either be:

- re-used in areas where test results indicate that it meets compliance targets so it can be re-used without treatment; or
- treatment of material on site to meet compliance targets so it can be re-used; or
- removal from site to a suitably licensed landfill or permitted treatment facility.

5.3.2 A Verification Report will be produced for the work and issued to the Client and the Local Authority.

5.4 Health and Safety

5.4.1 As outlined within the HSE publication "Successful Health and Safety Management – HSG65" this report should inform the development of safe systems of work and information as an input into the safety management system. The contents of this report may be used to supplement the contents of the Health and Safety File as required under the Construction Design and Management (CDM) Regulations 2007.

5.4.2 When developing risk control systems, it is recommended that reference be made to the CIRIA report 132 "A guide for safe working on contaminated sites" and the HSE document "Protection of workers and the public during the development of contaminated land – HSG66". All risk control measures should be in accordance with the guidelines laid down within the Management of Health and Safety at Work Regulations 1999.

APPENDICES

Appendix A

Service Constraints, Report Limitations and Planning Requirements

Service Constraints, Report Limitations and Planning Requirements

This consultancy contract, report and the site investigation (together comprise the "Services") were compiled and carried out by Sue Slaven for the Client as named on the front of this report (the "Client") based on a defined programme and scope of works and the terms of a contract between Sue Slaven and the Client. The Services were performed by Sue Slaven with all reasonable skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by Sue Slaven taking into account the limits of the scope of works required by the Client, the prevailing site conditions, the time scale involved and the resources, including financial and manpower resources, agreed between Sue Slaven and the Client. Sue Slaven cannot accept responsibility to any parties whatsoever, following the issue of this report, for any matters arising which may be considered outwith the agreed scope of works.

Other than that expressly contained in the above paragraph, Sue Slaven provides no other representation or warranty, whether express or implied, in relation to the Services. Unless otherwise agreed, this report has been prepared exclusively for the use and reliance of the Client in accordance with generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon, or transferred to, by any other party without the written agreement of Sue Slaven. If a third party relies on this report, it does so wholly at its own and sole risk and Sue Slaven disclaims any liability to such parties.

It is Sue Slaven's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of, or reliance upon, the report in those circumstances by the Client without Sue Slaven's review and advice shall be at the Client's sole and own risk.

The information contained in this report is protected by disclosure under Part 3 of the Environmental Information Regulations 2004 pursuant to the provisions of Regulation 12(5) without the consent in writing of Sue Slaven.

The report was prepared in the month stated on the front of the report and should be read in light of any subsequent changes in legislation, statutory requirements and industry practices. Ground conditions can also change over time and further investigations or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of Sue Slaven. In the absence of such written advice, reliance on the report in the future shall be at the Client's own and sole risk. Should Sue Slaven be requested to review the report in the future, Sue Slaven shall be entitled to additional payment at the then current rate or such other terms as may be agreed between Sue Slaven and the Client.

The observations and conclusions described in this report are based solely upon the Services that were provided pursuant to the agreement between the Client and Sue Slaven. Sue Slaven has not performed any observations, investigations, studies or testing not specifically set out or mentioned within this report. Sue Slaven is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, Sue Slaven did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, radon gas or other radioactive or hazardous materials.

The Services are based upon Sue Slaven's observations of existing physical conditions at the site gained from a walkover survey of the site, together with Sue Slaven's interpretation of information including documentation, obtained from third parties and from the Client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst Sue Slaven has no reason to doubt the accuracy and that it has been provided in full from those it was requested from, the items relied on have not been verified. No responsibility can be accepted for errors within

third party items presented in this report. Furthermore, Sue Slaven was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the Client or third parties, including laboratories and information services, during the performance of the Services. Sue Slaven is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Sue Slaven and including the doing of any independent investigation of the information provided to Sue Slaven save as otherwise provided in the terms of the contract between the Client and Sue Slaven.

Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

Planning Requirements

The National Planning Policy Framework (NPPF, 2012) has 12 core land-use planning principles, two of which directly relate to the potential for pollution and contaminated land:

- Requirement to "contribute to conserving and enhancing the natural environment and reducing pollution" and setting out of a preference for developments to be on land of "lesser environmental value"; and
- "encourage the effective use of land by re-using land that has been previously developed (brownfield land), providing that it is not of high environmental value.".

In accordance with the core principles of NPPF, Paragraph 109 clarifies that enhancing the natural environment includes:

- "preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability; and
- remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.".

Paragraph 121 of NPPF states that planning policies and decisions for developments should also ensure that:

- "the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;
- after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and
- adequate site investigation information, prepared by a competent person, is presented.".

This report has been prepared and authorised by staff that are competent as defined in the NPPF.

Unexploded Ordnance

Clients have a legal duty under the CDM 2015 Regulations to provide designers and contractors with project-specific health and safety information needed to identify hazards and risks. This includes the possibility of unexploded ordnance (UXO) being encountered on the site. Further details are given in CIRIA Report C681 (Stone et al 2009). A non-UXO specialist screening exercise has been carried out for the site by considering any evidence of UK defence activities on or near the site evident from the gathered desk study information and the unexploded aerial delivered bomb (UXB) regional risk maps produced by Zetica. Other data sources are available, but as a first stage screening exercise the freely available Zetica maps have been used. The level of risk stated is that determined by Zetica, a company experience in the desk study, field investigation and clearance of UXO/UXB.

Appendix B

Environmental Risk Assessment Methodology

ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY & TERMINOLOGY

LEGISLATION OVERVIEW

This report includes hazard identification and environmental risk assessment in line with the risk-based methods referred to in relevant UK legislation and guidance. Government environmental policy is based upon a "suitable for use approach," which is relevant to both the current use of land and to any proposed future use. The contaminated land regime is the statutory regime for remediation of contaminated land that causes an unacceptable level of risk and is set out in Part 2A of the Environmental Protection Act 1990 (EPA 1990). The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health or the wider environment given the current use and circumstances of the land. Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

> *"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:*
>
> *(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or*
> *(b) Pollution of controlled waters is being, or is likely to be, caused."*

In order to assist in establishing if there is a "*significant possibility of significant harm*" there must be a "*contaminant linkage"* for potential harm to exist. That means there must be source(s) of contamination, sensitive receptors present and a connection or pathway between the two. This combination of contaminant-pathway-receptor is termed a "contaminant linkage" or "CPR linkage."

Part IIA of The Environmental Protection Act 1990 is supported by a substantial quantity of guidance and other Regulations. Key implementing legislation of the Part 2A regime includes the Contaminated Land (England) Regulations 2006 (SI 2006/1380) as amended by the overarching legislation for the contaminated land regime, which implements the provisions of Part IIA of the Environmental Protection Act 1990 (as inserted by section 57 of the Environment Act 1995), came into force on 14th July 2000 together with recent amended regulations: Contaminated Land (England) (Amendment) Regulations 2012 (SI 2012/263). Revised Contaminated Land Statutory Guidance was published by DEFRA in April 2012. Part IIA defines the duties of Local Authorities in dealing with it. Part IIA places contaminated land responsibility as a part of planning and redevelopment process rather than Local Authority direct action except in situations of very high pollution risk.

In the planning process guidance is provided by National Planning Policy Framework (NPPF) of March 2012 which requires that a site which has been developed shall not be capable of being determined "contaminated land" under Part IIA. In practice, Planning Authorities require sites being developed to have a lower level of risk post development than the higher level of risk that is required in order to determine a site as being contaminated in accordance with Part IIA. This is to ensure that there is a suitable zone of safety below the level for Part IIA determination and prevent recently developed sites becoming reclassified as contaminated land if there are future legislative or technical changes (e.g. a substance is subsequently found to be more toxic than previously assessed this increases its hazard).

The criteria for assessing concentrations of contaminants and hence determining whether a site represents a hazard are based on a range of techniques, models and guidance. Within this context it is relevant to note that Government objectives are:

(a) to identify and remove unacceptable risks to human health and the environment;
(b) to seek to bring damaged land back into beneficial use;

(c) to seek to ensure that the cost burdens faced by individuals, companies and society as a whole are proportionate, manageable and economically sustainable.

These three objectives underlie the "suitable for use" approach to risk management and remediation of contaminated land. The "suitable for use" approach focuses on the risks caused by land contamination. The approach recognises that the risks presented by any given level of contamination will vary greatly according to the use of the land and a wide range of other factors, such as the underlying geology of the site. Risks therefore should be assessed on a site-by-site basis.

The "suitable for use" approach then consists of three elements:

(a) *ensuring that land is suitable for its current use* - in other words, identifying any land where contamination is causing unacceptable risks to human health and the environment, assessed since the current use and circumstances of the land, and returning such land to a condition where such risks no longer arise ("remediating" the land); the contaminated land regime provides the regulatory mechanisms to achieve this;

(b) *ensuring that land is made suitable for any new use, as planning permission is given for that new use* - in other words, assessing the potential risks from contamination, on the basis of the proposed future use and circumstances, before official permission is given for the development and, where necessary to avoid unacceptable risks to human health and the environment, remediating the land before the new use commences; this is the role of the town and country planning and building control regimes; and

(c) *limiting requirements for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to the current use or future use of the land for which planning permission is being sought* - in other words, recognising that the risks from contaminated land can be satisfactory assessed only in the context of specific uses of the land (whether current or proposed), and that any attempt to guess what might be needed at some time in the future for other uses is likely to result either in premature work (thereby running the risk of distorting social, economic and environmental priorities) or in unnecessary work (thereby wasting resources).

The mere presence of contaminants does not therefore necessarily warrant action, and consideration must be given to the scale of risk involved for the use that the site has, and will have in the future.

OVERALL METHODOLOGY

The work presented in this report has been carried out in general accordance with recognised best practice as detailed in guidance documents such as in the CLR 11 Model Procedures for the Management of Land Contamination (Environment Agency, 2004), and BS10175:2011+A1 2013. Important aspects of the risk assessment process are transparency and justification. The particular rationale behind the risk assessments presented is given in this appendix.

The first stage of a two-staged investigation and assessment of a site is the Preliminary Investigation (BS 10175:2011), often referred to as the Phase 1 Study, comprising desk study and walk-over survey, which culminates in the Preliminary Risk Assessment. A preliminary conceptual site model (CSM) is developed which identifies potential geotechnical and geo-environmental hazards and the qualitative degree of risk associated with them. From the geo-environmental perspective, the Hazard Identification process uses professional judgement to evaluate all the hazards in terms of potential contaminant linkages (of contaminant source-pathway-receptor). Potential contaminant linkages are potentially unacceptable risks in terms of the current

contaminated land regime legal framework and require either remediation or further assessment. These are normally addressed via intrusive ground investigation and generic risk assessment.

The second stage is the Ground Investigation, Generic Risk Assessment and Geotechnical Interpretation. This represents the further assessment mentioned above. The scope of the Ground Investigation is based on the findings of the Preliminary Risk Assessment and is designed to reduce uncertainty in the geotechnical and geoenvironmental hazard identification. The Ground Investigation comprises fieldwork, laboratory testing and usually also on-site monitoring. The Ground Investigation may include the Exploratory, Main and Supplementary Investigations described in BS 10175:2011+A1 2013. The results of the Ground Investigation reduce uncertainty in the geotechnical and geoenvironmental risks. Depending on the findings more detailed investigations or assessments may be required.

PRELIMINARY RISK ASSESSMENT

Current practice recommends that the determination of potential liabilities that could arise from land contamination be carried out using the process of risk assessment, whereby "risk" is defined as:

"(a) The probability, or frequency, or occurrence of a defined hazard; and
(b) The magnitude (including the seriousness) of the consequences."

The UK's approach to the assessment of environmental risk is set out in by the Department of the Environment Transport and the Regions (2000) publication "A Guide to Risk Assessment and Risk Management for Environmental Protection" (also called Greenleaves II). This established an iterative, systematic staged process which comprises:

(a) Hazard identification;
(b) Hazard assessment;
(c) Risk estimation;
(d) Risk evaluation;
(e) Risk assessment;

At each stage during the development process, the above steps are repeated as more detailed information becomes available for the site.

For an environmental risk to be present, all three of the following elements must be present:

- Source/Contaminant: hazardous substance that has the potential to cause adverse impacts;
- Receptor: target that may be affected by contamination: examples include human occupants/users of site, water resources (rivers or groundwater), or structures;
- Pathway: a viable route whereby a hazardous substance may come into contact with the receptor.

The absence of one or more of each component (contaminant, pathway, receptor) would prevent a contaminant linkage being established and there would be no significant environmental risk.

The identification of potential contaminant linkages is based on a Conceptual Model of the site, which is subject to continual refinement as additional data becomes available. As part of a Preliminary Risk Assessment (Desk Study and site walk over) a Preliminary Conceptual Site Model (PCSM) is formed. Based on the PCSM, potential contaminant linkages can be assessed. If the PCSM and hazard assessment indicate that a contaminant linkage is not of significance then no further assessment or action is required for this linkage. For each significant and potential linkage, a risk assessment is carried out. The linkages which potentially pose significant risks may

require a variety of responses ranging from immediate remedial action or risk management or, more commonly, further investigation and risk assessment. This next stage is termed a Phase II Main Site Investigation and should provide additional data to allow refinement of the Conceptual Site Model and assess the level of risk from each contaminant linkage.

Definition of Risk Assessment Terminology

The criteria used for risk assessment are broadly based on those presented in DETR's "A Guide to Risk Assessment and Risk Management for Environmental Protection" (2000). The severity of the risk is classified according to the criteria in Table B.1 below:

Table B.1 Severity/Consequence of Risk

Severe	Acute risks to human health. Catastrophic damage to buildings/property (e.g. by explosion). Direct pollution of sensitive water receptors or serious pollution of other controlled water (watercourses or groundwater) bodies.
Medium	Harm to human health from long-term exposure. Slight pollution of sensitive controlled waters (surface waters or aquifers) or pollution of other water bodies. Significant effects on sensitive ecosystems or species.
Mild	No significant harm to human health in either short or long term. No pollution of sensitive controlled waters, no more than slight pollution of non-sensitive waters. Significant damage to buildings or structures. Requirement for protective equipment during site works to mitigate health effects.
Negligible	Damage to non-sensitive ecosystems or species. Minor damage to buildings or structures. No harm or pollution of water.

The probability of the risk occurring is classified according to criteria given in Table B.2 below:

Table B.2: Probability of Risk Occurring

High likelihood	Contaminant linkage may be present, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.
Medium/Reasonably Foreseeable	Contaminant linkage may be present, and it is probable that the risk will occur over the long term.
Low/Unlikely	Contaminant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Negligible/ Not credible	Contaminant linkage may be present but the circumstances under which harm would occur are improbable.

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table B.3 below:

Table B.3: Comparison of Severity and Probability

		Severity			
		Severe	**Medium**	**Mild**	**Negligible**
Probability	**High likelihood**	Very High Risk	High Risk	Medium/Low Risk	Low Risk
	Medium/Reasonably Foreseeable	High Risk	Medium Risk	Low Risk	Near Zero
	Low/Unlikely	High/Medium Risk	Medium/Low Risk	Low Risk	Near Zero

	Negligible/ Not credible	Medium/Low Risk	Low Risk	Low Risk	Near Zero

The various risk rankings provide guidance for recommended actions, whether this is:

AR - Action Required, Remediation or mitigation or site investigation works required
SIR - Site Investigation Required, further assessment is required.
NAR - No Action Required.

A description of the evaluated risk is as follows:

Table B.4 – Description of the Classified Risks and Likely Action Required

Evaluated Risk	Recommended Actions
Very High Risk	AR: 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 undertaken already) and remediation are likely to be required.
High Risk	AR: 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 undertaken already) is required and remedial works may be necessary in the short term and are likely over the long term.
Moderate Risk	SI: It is possible that harm could arise to a designated receptor from an identified hazard. However, it is 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. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low Risk	NAR: It is possible that harm could arise to a designated receptor from an identified hazard, but there is a low likelihood of this hazard occurring and if realised, harm would at worst normally be mild.
Near Zero	NAR: There is a negligible possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

GENERIC QUANTITATIVE RISK ASSESSMENT

In the following sections, the current UK guidance on risks to the following receptors are discussed: human health, plant life and controlled waters

Human Health

The overall methodology for assessing the risk to human health from potential contaminants in soil is set out in the Environment Agency's guidance "Using Soil Guideline Values" SC050021/SGV Introduction, March 2009 and using the CLEA 1.06 model software. The generic assessment criteria are in accordance with the following:

- Science Report SC050021/SR2: Human health toxicological assessment of contaminants in soil;
- Science Report SC050021/SR3: Updated technical background to the CLEA model;
- Science Report SC050021/SR4: CLEA Software (Version) Handbook;
- Toxicological reports and SGV technical notes;
- Toxicological data published by LQM/CIEH (2009) and CL:AIRE/EIC/AGS (2009)
- DEFRA Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (December 2013).
- LQM/CIEH Suitable 4 Use Levels (S4ULs) for Human Health Risk Assessment

In March 2014 six 'proposed' Category 4 Screening Levels (pC4SL) were issued by Defra. These screening values are considered to be within Category 4 as defined in the Contaminated Land Statutory Guidance and indicate

safe levels for new developments passing through the planning system. The SGV for lead has been withdrawn, and the pC4SL for lead has been derived using current best practice. In January 2015 LQM/CIEH published S4ULs for 89 contaminants in accordance with the C4SL methodology.

Note that groundwater contamination may pose a risk to human health but that there are no relevant generic assessment criteria available for comparison.

Phytotoxic Risks
Generic assessment of phytotoxicity is by comparison with guideline values presented in the British Standard for Topsoil and the MAFF document "Code of Good agricultural practice for the protection of soil", October 1998. This is in accordance with CLR's reference to DEFRA notice CLAN 4/04.

Controlled Waters
Risks to controlled waters (groundwater and surface waters) from contaminants are assessed in accordance with the EA documents Groundwater Protection: Policy and Practice GP3 (2012) and Remedial Targets Methodology (RTM, 2006). Pollutant inputs from contaminated land sites are considered as passive inputs under the European Water Framework Directive (2000/60/EC) (WFD) and its daughter Directives, and as such are regulated under the Environment Agency's 'limit' pollution objective. Acceptable water quality targets (WQT) are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)). The risk posed to controlled waters from total soil concentrations cannot be directly assessed. The risk is assessed either by comparison of results of leachate tests carried out on soil samples, or from the direct testing of samples of groundwater to screening criteria. Leachate testing generally forms a conservative assessment and is not appropriate for organic contaminants.

CURRENT GUIDANCE ON INTERPRETATION OF CHEMICAL ANALYSIS OF SOILS

Contaminated land is defined under law through Part IIA of the Environmental Protection Act 1990, implemented through Section 57 of the Environment Act 1995. This supports a 'suitable for use' based approach to the risk assessment of potentially contaminated land. The site-specific risk assessment is based upon assessment of plausible contaminant linkages, referred to as the contaminant-pathway- receptor model, based upon the current or proposed use of the site.

Before undertaking a risk assessment, a conceptual site model is devised in order to identify the potential contaminants, pathways and receptors. The individual contaminants, pathways and receptors then need to be further investigated in order to refine the initial assessment and risk assessment undertaken.

In March 2002, the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency published the Contaminated Land Exposure Assessment (CLEA) Model and a series of related reports. These were designed to provide a scientifically based framework for the assessment of chronic risks to human health from contaminated land. These reports (CLR7-10) together with associated "SGV" documents were withdrawn and the following documents have been published as revised guidance to the CLEA assessment:

- Environment Agency : 2008: Using Soil Guideline Values SC050021/SGV Introduction, March 2008.
- Environment Agency : 2008: Science Report SC050021/SR2: Human health toxicological assessment of contaminants in soil.
- Environment Agency : 2008: Science Report SC050021/SR3: Updated technical background to the CLEA model.
- Environment Agency : 2008 :Compilation of Data for Priority Organic Contaminants for Derivation of Soil Guideline Values Science report SC050021/SR7
- Science Report SC050021/SR4: CLEA Software (Version) Handbook.

- DEFRA Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (December 2013).
- LQM/CIEH Suitable 4 Use Levels for Human Health Risk Assessment

Additional guidance on statistical assessment replacing CLR 7 is partly provided in:

- CL:AIRE: 2009: Guidance on Comparing Data With a Critical Concentration

A different approach to the statistical appraisal of data is required depending on whether the assessment of risk is to assess whether land is Contaminated Land in accordance with regulations, or whether the assessment is to assess whether the site is suitable for new development in according with Planning guidance. This is discussed further in CL:AIRE: 2009 "Guidance on Comparing Data With a Critical Concentration".

The introduction of the Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) reassessed the CLEA Model and the derived SGVs (and associated GACs calculated using the model). This re-assessment concluded that the SGVs/GACs were conservative screening criteria for determining the suitability of soil with regard to the risk to human health under the planning regime and defined a new upper limit for planning purposes which is the boundary between the new Category 3 and 4. In March and September 2014 Defra issued guidance on these new Category 4 Screening Levels (C4SL) and these are discussed further below.

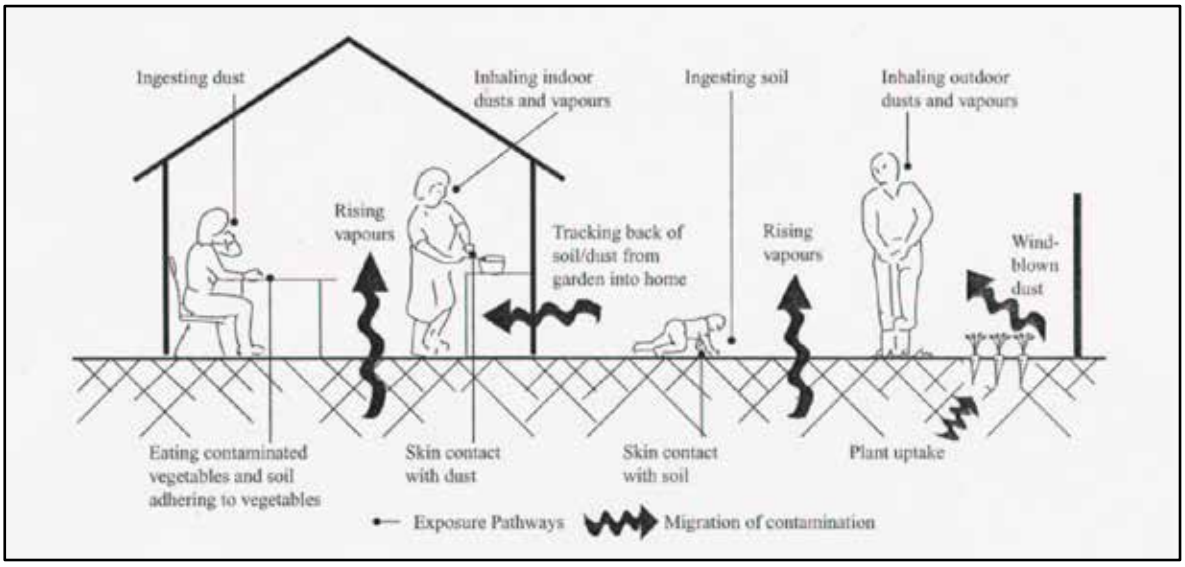
Soil Guideline Values

A program for the derivation of SGVs based on the above guidance is provided by the Environment Agency and is entitled "CLEA Software Version 1.06". These reports, together with supporting toxicology reviews ("Tox" or Supplementary Information Reports) for individual substances (which will be gradually updated), Soil Guideline Value Reports and other guidance referred to in the above documents, provide guidance and the scientific basis for assessing the risk to human health from potential contaminants. Soil Guideline Value Reports (SGV Reports) have been published for a number of contaminants and these are published on the Environment Agency website. Eventually the reports will include SGVs for:

- heavy metals and other inorganic compounds: arsenic, cadmium, chromium, cyanide, lead (now withdrawn), mercury, nickel (now withdrawn), and selenium;
- benzene, ethylbenzene, toluene and xylenes;
- phenol;
- dioxins and dioxin-like polychlorinated biphenyls (PCBs);
- polycyclic aromatic hydrocarbons (PAHs) – 11 substances.

In addition, CIEH through LQM and the EIC have published generic assessment criteria (GACs) for a wide variety of other parameters including metals, hydrocarbons, chlorinated aliphatic compounds, PAHs and explosive substances for three standard land uses. These have been produced to supplement the Environment Agency guidance. These GACs will be replaced by SGVs when or if the Environment Agency publishes any more SGVs.

The CLEA model has been developed to calculate an estimated tolerable daily soil intake (TDSI) for site users given a set 'default' exposure pathways. Ten human exposure pathways are covered in the CLEA model as presented below:



- **Ingestion**
  - ingestion of outdoor soil;
  - ingestion of indoor dust;
  - ingestion of home grown vegetables;
  - ingestion of soil attached to home grown vegetables.

- **Dermal Contact**
  - dermal contact with outdoor soil;
  - dermal contact with indoor dust.

- **Inhalation**
  - inhalation of outdoor dust;
  - inhalation of indoor dust;
  - inhalation of outdoor soil vapour;
  - inhalation of indoor soil vapour.

It should be noted that there are other potential exposure pathways on some sites not included in the CLEA model e.g. certain organic compounds can pass through plastic water pipes into drinking water supply.

The presence and/or significance of each of the above exposure pathways are dependent on the type of land use being considered and the nature of the contaminant under scrutiny. Accordingly, the CLEA model considers for principle 'default' land use types and makes a series of 'default' assumptions with regard to human exposure frequency, duration and critical human target groups for each land use considered:

- residential land use;
- allotments;
- commercial and industrial land use.

The land use categories defined in the CLEA are detailed below.

Residential: This land use category assumes that people live in a variety of dwellings including terraced, detached and semi-detached houses up to two storeys high. The structure of buildings varies. Default parameters for building materials and building design are included in CLEA documents to calculate the relevant multi-layer diffusion coefficients for vapour intrusion and to model indoor vapour intrusion.

The CLEA model assumes that regardless of the style of housing the residents will have access to either a private garden or community open space nearby, and that soil tracked into the home will form indoor dust. It allows for the ingestion pathways from home grown vegetables.

Allotments: The CLEA model incorporates an assessment of land provided by local authorities specifically for people to grow fruit and vegetables for their own consumption. Consumption of such fruit and vegetables present several exposure pathways; plants absorb contaminants mainly via water uptake through roots, the contaminants move to edible portions of plants via translocation and contaminated soil particles become trapped in the skin and between leaves. At present the model fails to account for exposure through the consumption of animals, and their products (e.g. eggs), which have been reared on contaminated land.

Commercial/Industrial: Although there are a wide variety of workplaces and work-related activities, the CLEA assessment of this land-use assumes that work occurs in a permanent, three-storey structure, where employees spend most time indoors, conducting office-based or light physical work. The model assumes employees sit outside during breaks for most of the year. Limitations in applying this land-use to different industries is detailed in EA publication "Updated technical background to the CLEA model" (2011). The generic model assumes that the site would not be covered by hardstanding. Risk of exposure to contaminants would be clearly less where commercial land is essentially all buildings and hardstanding.

Based on the assumptions of each land use and the associated applicable exposure pathways, a 'Soil Guideline Value' (SGV) may be calculated for each contaminant under consideration for a particular land use in order to determine whether certain contaminant soil concentrations pose a significant risk to human health. The primary purpose of the CLEA SGVs are as 'trigger values' – indicators to a risk assessor that soil concentrations below this level require no further assessment as it can be assumed that the soil is suitable for the proposed use. Where soil concentrations occur above the SGV then further assessment of the results is required. The Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) which came into force in early April 2012 provides new clarity on the assessment of risk where soil concentrations exceed the SGV. The guidance introduces a four stage classification system relating to concentration of contaminants and the assessed risk which indicates appropriate actions. Category 1 and 2 sites are classified as "Contaminated Land" as defined in Part IIA of The Environmental Protection Act (1990). Category 3 and 4 sites are not considered as "Contaminated Land" in accordance with the Act. This can be explained using the figure on the following page.

There are also difficulties in establishing soil concentrations of contaminants beyond which risks from exposure to these contaminants would be 'unacceptable' and that they would lead to "significant possibility of significant harm" as defined in Part IIA of The Environmental Protection Act (1990) and determine that the land is "contaminated." This ultimately requires detailed 'toxicological' information of the health effects of individual contaminants and also a scientific judgement on what constitutes an 'unacceptable' risk. It is for local authorities or the Environment Agency to determine whether a particular site is contaminated land and it is for local Planning Authorities to determine whether land affected by contamination can be redeveloped.

Given the SGVs have been derived only for a limited number of contaminants and there was little prospect of further SGVs being published, two professional groupings have produced Generic Assessment Criteria (GACs) in accordance with the CLEA model for many additional contaminants. These GACs were recognised in the new Contaminated Land Statutory Guidance (DEFRA, 2012) and have been produced as follows:

Nathaniel CP, McCaffrey C, Ashmore MH, Cheng NPS GROUP, Gillett A, Ogden R & Scott D. The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd edition). Land Quality Press, Nottingham. 2009. Publication Number: S4UL3244

CL:AIRE/EIC/AGS. Soil Generic Assessment Criteria (GAC) for Human Health Risk Assessment. Contaminated Land: Applications in Real Environments, Environment Industries Commission & Association of Geotechnical and Environmental Specialists. December 2009.

Category 4 Screening Levels and LQM/CIEH Suitable 4 Use Levels

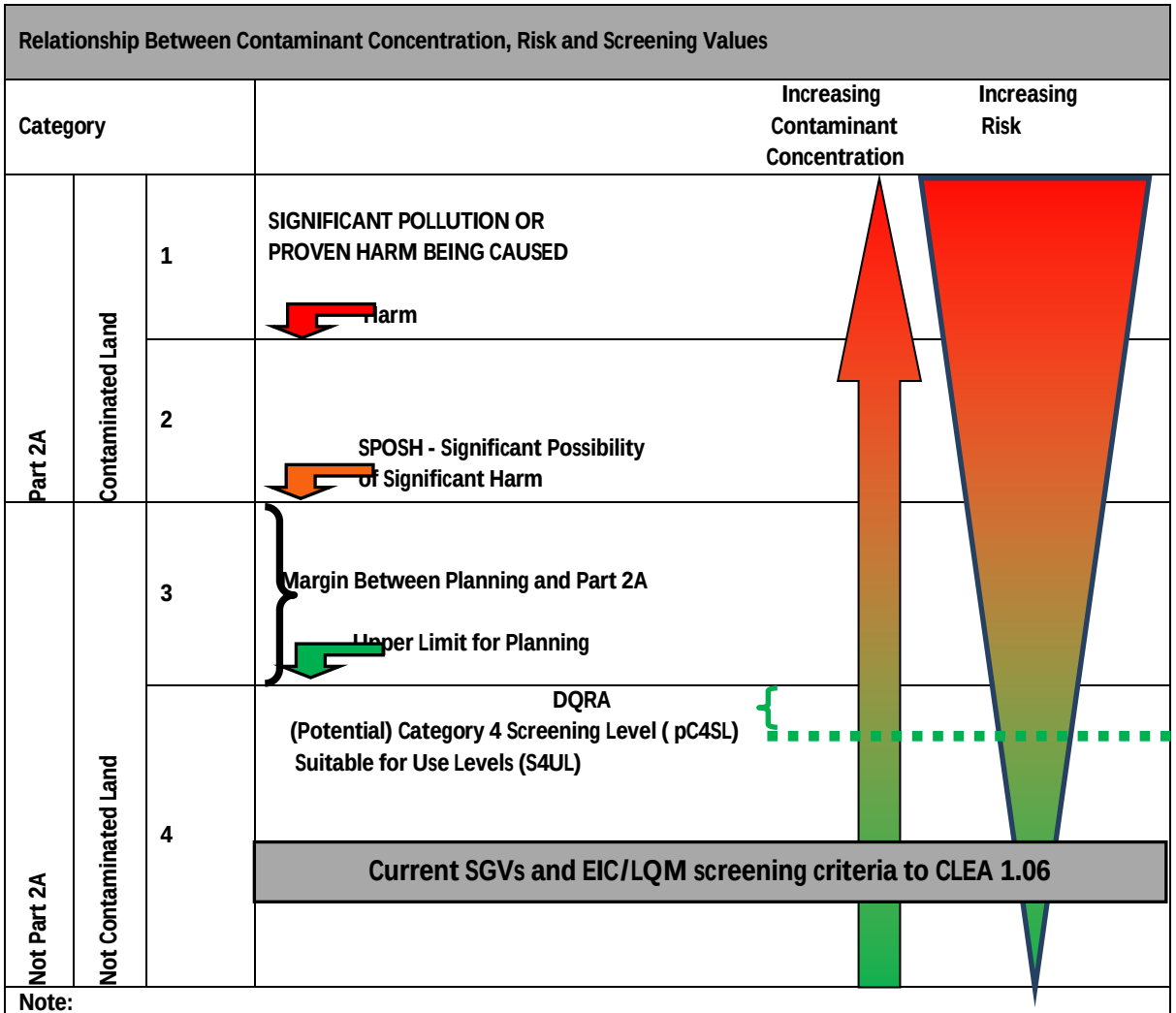
For new developments progressing through the planning regime, it is desirable that the soil concentrations are within Category 4 where there is a valid contaminant linkage. The upper boundary between Category 4 and 3 is not defined in the guidance. This boundary can also be better defined by carrying out a Detailed Quantified Risk Assessment (DQRA), as discussed below.

In December 2013 Defra issued the findings of a research project undertaken by CL:AIRE to set out the framework by which potential Category 4 Screening Levels (pC4SL) may be derived. The report was not designed to produce 'final' C4SL as the steering group producing the report believes that final C4SL should be set by a 'relevant authority' (e.g. Defra), the toxicological framework proposed has not been reviewed by the Committee on Toxicity and the document has yet to be subject to peer review.

In March 2014, appendices to the main Defra report were published detailing the derivation of pC4SL for 6 contaminants and other appendices regarding a review of the CIEH/CL:AIRE statistics guidance and sensitivity analysis. For each contaminant, a range of pC4SL have been produced relating to modifying toxicological parameters only, modifying exposure parameters only or by modifying both. It should be noted that the pC4SL produced for lead (the SGV was withdrawn in 2011) has undertaken a relatively large toxicological review in relation to modelling blood lead concentrations. pC4SLs have been produced for:

- Arsenic;
- Benzene;
- Benzo(a)pyrene (as a surrogate marker for PAHs);
- Cadmium;
- Chromium (VI); and
- Lead

As previously discussed the values were initially published as 'potential' C4SL but have become 'final' following DEFRA having issued a policy decision letter indicating that they are to be used in the planning regime (letter of 3rd September 2014). It is considered that the pC4SL provide a simple test for deciding whether land is suitable for use without any remediation. The pC4SL represent a new set of screening levels that are more pragmatic (but strongly precautionary) compared to the existing soil guideline values (SGVs and the other GACs calculate in accordance with the existing CLEA methodology). The pC4SL provide cautious estimates of contaminant concentrations in soil that are still considered to present an acceptable level of risk, within the context of Part 2A, by combining information on toxicology, exposure assessment and normal levels of exposure to these contaminants. pC4SL values should not be seen as 'SPOSH values.' Exceeding a pC4SL means that further investigation is required, not that the land is necessarily contaminated. In January 2015, LQM published Suitable 4 Use Levels (S4ULs) for a further 89 contaminants using the Defra C4SL methodology. In a similar manner to the pC4SLs, no authoritative review has been undertaken although the approach and quality of the work undertaken is widely accepted as being of high quality.



Note:
The vertical scale should not be considered as being linear and will be site and contaminant specific.

- SPOSH concentrations could be 10 to 100 times the SGV/EIC/LQM screening concentration.
- C4SL were issued as 'potential' but have become 'final' following DEFRA having issued a policy decision letter indicating that they are to be used in the planning regime (letter of 3rd September 2014).

Lead

The SGV for lead was withdrawn in 2011 and is not used in this report. The pC4SL for lead provides a technically robust and conservative assessment tool using significantly updated toxicological modelling in line with current scientific understanding of lead toxicology.

Public Open Space

The Defra report (December 2013) has also introduced exposure scenarios for two other commonly occurring land uses which require assessment (under the planning and Part 2A regimes) on a relatively frequent basis. These exposure scenarios are:

- Public Open Space – Space Near Residential Housing (POS_{resi}); and
- Public Open Space – Public Park (POS_{park}).

Potential use of pC4SL relating to Public Open Space (POS) require care due to the significant variability in exposure characteristics. For example, POS may include:

- Children's play areas, public parks where children practise sport several times a week and teenagers only once a week;
- Grassed areas adjacent to residential properties which are rarely used;
- Dedicated sports grounds where exposure is only to players and groundworkers; and
- Nature reserves or open ground with low level activity (for example, dog walking).

Within the Defra report (December 2013) the following exposure scenarios have been modelled as these are considered the most important for potential exposure for the critical receptor i.e. young children:

- Green open space close to housing, including tracking back of soil (POS_{resi}); and
- Park-type scenario where distance is considered sufficient to discount tracking back of soil (POS_{park}).

Detailed Quantified Risk Assessment (DQRA)

SGVs, GACs, pC4SL and S4ULs are based on a number of basic assumptions. There are two main options for developing Site Specific Assessment Criteria (SSAC) by adjusting the CLEA model so that they have greater relevance to the site:

- **Simple adjustment of the generic SGV / C4SL model**. Such adjustment is restricted to the choice of exposure routes selected for the generic land use, building type, soil type and soil organic matter content within the CLEA software.

- **Detailed adjustment.** It may be relevant to make greater modifications to the model due to the specific use of the land in question. This can include modification to any parameter value, including exposure assumptions, building parameters, and the choice and application of fate and transport models. This is equally relevant to site-specific modifications of existing generic land uses, the development of new land uses, and the inclusion of additional exposure pathways. Much of this can be undertaken using the CLEA software. Depending on the complexity of the detailed adjustments required, it may be necessary to use other tools either alone or in conjunction with the CLEA software. Both options should follow established protocols for DQRA and require sufficient justification and supporting information for the adjustments made. Detailed adjustments are likely to require substantially greater technical justification and supporting documentation, especially if modifications are based on information not contained within the SGV framework documents.

The two choices present the risk assessor with three options/decisions:

(1) Use a published SGV/GAC/pC4SL/S4UL if it can be demonstrated that the assumptions inherent in the value are appropriate to the site in question. If they are not, proceed to either option 2 or 3 below.

(2) Make simple site-specific adjustments to the generic exposure model used to derive the SSAC. Three examples of when this could be appropriate are:

   a. High density residential development with no exposed contaminated soil at surface. It is appropriate in this case to consider the relevance of direct contact pathways and consumption of homegrown produce.

b. Soil type is significantly different (specifically when soil type is likely to be less protective e.g. made ground) to that assumed in the SGV/GAC/pC4SL/S4UL.

c. Soil organic matter content is significantly different to that assumed in the derivation of the SGV/GAC/pC4SL/S4UL.

(3) If simple adjustments are not sufficient to reflect site conditions, undertake a DQRA. This may be undertaken using the CLEA software or by using an alternative risk assessment methodology that is relevant, appropriate, authoritative and scientifically based. Changes to toxicological end points may also be considered, although this should only be undertaken by a toxicology expert. In the context of this guidance, simple adjustments of a generic land use scenario for soil type or SOM content for example are not considered sufficient to be classed as a DQRA.

DQRAs should be conducted with the agreement of the local authority (or the Environment Agency) since it is the authority that determines whether land is Contaminated Land or whether Planning Permission for a new development may be granted.

Representative Data

The type, quantity and quality of the available soil data influence the method chosen to obtain a site representative soil concentration that is compared with a SGV/GAC/pC4SL/S4UL in the screening process. The soil data should be representative of the exposure scenario being considered. This can include factors such as:

- averaging area over which exposure occurs;
- sample depth;
- heterogeneity of soil

where the 'averaging area' is defined as:

That area (together with a consideration of depth) of soil to which a receptor is exposed or which otherwise contributes to the creation of hazardous conditions'.

Site investigations take discrete samples from a given area (and to a certain depth). It must be assumed that these samples are to some degree representative of the contaminant concentration throughout that volume of soil. The critical soil volume (taking into account area and depth) which might be usefully compared with a SGV/GAC/pC4SL/S4UL is a site-specific decision, but a starting point is the generic land use scenarios used in the derivation of the SGV/GAC/pC4SL/S4UL. The critical soil volume depends on two factors:

- Contaminant distribution and vertical profile (bands of highly contaminated material or lateral hot spots should not necessarily be averaged out with more extensive cleaner areas of soil without justification)
- Contribution to average exposure underpinning the SGV. Direct contact exposure pathways depend on the adult or child coming into contact with near-surface soils and the area over which that exposure occurs is usually important (i.e. the averaging area). Vapour pathways are less dependent on surface area, for example vapour intrusion may result from a highly concentrated hot spot beneath a building leading to elevated average indoor air concentrations. For the three standard land uses for which SGVs are derived, relevant considerations are:
- For the standard **residential or allotment land use**, the critical soil volume is the area of an individual garden, communal play area or working plot from the surface to a depth of between 0.5m and 1.0m. This is the ground over which children are most likely to come into contact with soil or from which vegetable and fruit produce will be harvested. In the case of volatile

contaminants, it may also be appropriate to consider the volume of soil underneath the footprint of the building although vapour intrusion may be driven by a soil volume much smaller than this if the contaminant source is highly concentrated.

- For the standard **commercial land use**, the critical soil volume has to be decided on a case-by- case basis due to the wide range of possible site layouts. However, for non-volatile contaminants, landscaped and recreational areas around the perimeter of office buildings are likely to be most important. For volatile contaminants, the footprint occupied by the building itself should also be considered.
- For **most exposure pathways**, the contamination is assumed to be at or within one metre of the surface.

The use of averaging areas must be justified on the basis of relevance to the exposure scenario. SGVs are relevant only when the exposure assumptions inherent in them are appropriate for the identified exposure averaging area. Further guidance on critical soil volumes and the consideration of averaging exposure areas can be found in:

Secondary model procedure for the development of appropriate soil sampling strategies for land contamination (Environment Agency, 2000);
Guidance on comparing soil contamination data with a critical concentration (CIEH/CL:AIRE, 2009); and Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Appendix I (Defra December 2013, March 2014)

It is the mean soil concentration for the individual contaminant within an individual averaging area, which is compared to the SGV. However, as contaminant concentrations vary across a site, and sampling and analysis will introduce measurement errors, the comparison between measured mean concentration and the SGV must take this uncertainty into account.

There are two principal options available to obtain site representative soil concentrations from a site investigation dataset; statistical and non-statistical methods. Data objectives, quality and quantity are likely to determine which approach is most appropriate. If statistical methods such as those presented in CIEH/CL:AIRE (2011) are to be used, sufficient data need to be available or obtained. No one single statistical approach is applicable to all sites and circumstances. The wider range of robust statistical techniques developed by organisations including the US Environmental Protection Agency (USEPA) are also important tools. Risk assessors should choose an appropriate statistical approach on the basis of the specific site and the decision that is being made. For further guidance on the appropriate use of statistical approaches, refer to USEPA 2006 or good environmental monitoring statistics textbooks.

When statistical approaches are inappropriate (this will depend on the objectives of the site investigation), individual or composite samples should be compared directly to the SGV. Guidance on use of alternative data handling approaches such as the use of composite sampling can be found in documents such as:

Verification of remediation of land contamination (Environment Agency, 2010);
Sampling and testing of wastes to meet landfill Waste Acceptance Criteria (Environment Agency, 2005);
Guidance on choosing a sampling design for environmental data collection (USEPA, 2002);
Soil Quality – Sampling, ISO 10381 series (ISO, 2002–2007).

The statistical tests should not be used as arbiters for decisions under Part 2A. They are an additional, useful line of evidence to assist in decision-making. The implications of the basis for the derivation of the site representative soil concentration must be taken into account in any decision-making process and clearly documented.

Where the statistical tests are conducted in accordance with the method described in CL:AIRE 2009:

- For the Planning situation, it has to be demonstrated that the concentration of contaminants is low compared to the pC4SL/S4UL or SSAC. All of the test data should be below the screening criteria and no statistical analysis is required or if there are exceedances of the criteria then a statistical assessment is required. For the statistical assessment, this decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is lower than the screening criteria.
- For the Part 2A scenario the regulator needs to determine whether the concentration of contaminants is greater than the SGV/GAC/pC4SL/S4UL or SSAC. This decision is based on whether there is at least a 95% confidence level that the true mean of the dataset is higher than the SSAC. However, the regulator may proceed with determination if there is just a 51% probability, "on the balance of probabilities."

If the screening levels are exceeded then more sophisticated quantitative risk assessment can be undertaken or remedial action may be taken to break the contaminant linkages. The benefits of undertaking a quantitative risk assessment must be weighed against the likelihood that it will bring about cost savings in the proposed remediation. Further information about the use of soil guideline values is provided in Environment Agency : 2008: Using Soil Guideline Values SC050021/SGV Introduction, March 2008.

GENERIC RISK ASSESSMENT CRITERIA FOR RISK TO PLANTS

Soil contaminants, if present at sufficient concentrations, can have an adverse effect on the plant population. Phytotoxic effects can be manifested by a variety of responses, such as growth inhibition, interference with plant processes, contaminant-induced nutrient deficiencies and chlorosis (yellowing of leaves). All chemicals are probably capable of causing phytotoxic effects. Thus, the phytotoxic potential of substances is dependent on the concentrations capable of having adverse effects on plants and the concentrations likely to be found at contaminated sites. Phytotoxicity is a difficult parameter to quantify given that experimental techniques vary widely and variations exist in plant tolerances, soil effects and synergistic/antagonistic reactions between chemicals. Contaminants may be taken up and accumulated by plants through a range of mechanisms. The principal pathways are active and/or passive uptake through the plant root, adsorption to root surfaces and volatilisation from the soil surface followed by foliar uptake. After plant uptake, contaminants may be metabolised or excreted, or they may be bioaccumulated and this is highly species dependant. Many of the substances capable of adversely affecting vegetation exert this effect because of their water solubility, a characteristic that could result in their transport from contaminated sites into adjacent locations where the chemical may generate a phytotoxic response. This could be important if, for example, the adjacent site has important conservation status.

The concentration in soil at which substances become phytotoxic depend on a range of factors including plant type, soil type, pH, the form and availability of the contaminant and other vegetation stress factors that may be present (such as drought). Some plants (including some rare plants will only grow in soils where there are relatively high concentrations which would be phytotoxic to other species. Whilst many contaminants may be phytotoxic, data are limited. Some heavy metals are essential as trace elements for plant growth but may become toxic at higher concentrations.

TerraConsult has carried out a review of a number of current and former guidance documents and other texts on phytotoxicity. It is not possible to produce a definitive list of phytotoxic substances on account of the variables mentioned above. However, a number of metals are repeatedly cited as commonly occurring priority pollutants. As a result, the following list is adopted by TerraConsult as indicators of the potential for phytotoxicity: As, Cr, Cu, Ni and Zn (note that Boron has been excluded from this list because the more modern studies do not assess this).

As the CLEA framework is a risk based approach, applied to humans, an alternative strategy is required to assess the risk to plants from substances that are phytotoxic. Reference to published criteria and background concentrations can help put site data into context. Published assessment criteria for the protection of plant life from a number of countries are given in the following Table. The most authoritative source is the British Standard for topsoil, but this only lists three elements. CLR 11 states that the ICRCL Guidance Note 70/90 can be used for initial screening criteria. This approach has been adopted by TerraConsult where BS3882 is lacking, but where an ICRCL 70/90 criterion is lacking, the lowest criterion in Table below from, firstly UK, and, secondly, European and then other worldwide criteria. The adopted criteria are highlighted in the table 3.8. The MAFF value of 250 mg/kg has been chosen for As over the ICRCL value of 50 mg/kg as MAFF explains the 50 is applicable to vegetables and human health, whereas 250 is applicable to the plants themselves.

Table B.5: Published Assessment Criteria for Phytotoxic Elements (mg/kg)

Reference	As	CR (Total)	Cr (III)	Cr (VI)	Cu	Ni	Zn
British Standard for topsoil (BS3882:2007)	-	-	-	-	200 (pH >7) 135 (pH 6-7) 100 (pH 5.5-6.0)	110 (pH >7) 75 (pH 6-7) 60 (pH 5.5-6.0)	300 (pH >7) 200 (pH 6-7) 200 (pH 5.5-6.0)
MAFF Code of Good Agricultural Practice for the Protection of Soil (1998)	250	-	400 for sites containing sewage and sludge	-	500 (grass) but may fall to 250 for clover and sensitive species (at pH>6)	110 (pH>7) 75 (pH 6-7) 60 (pH 5.5-6.0)	1000 (clover & grass at pH 6), may fall to 300 for sensitive species (at pH 6-7)
ICRCL 59/83 (1987) now withdrawn for human health assessment	-	-	-	-	130	70	300
ICRCL 70/90 (1990) threshold trigger value	50	-	-	25 *	250	-	1000
Dutch ecotoxicological intervention value (Swartjes 1993 & 1994)	40	230	-	7	190	-	-
Australian Guideline B(1) (1999), Interim Urban Ecological Investigation Level (EIL). Soils not generally considered phytotoxic below these EILs.	20	-	400	1	100	60	200
New Zealand guidelines for timber treatment sites (1977), estimated based on Cu bioavailability *	-	-	-	-	500 - 1000 clay soils	-	-

Reference	As	CR (Total)	Cr (III)	Cr (VI)	Cu	Ni	Zn
New Zealand guidelines for timber treatment sites (1977), soil criteria for protection of plant life (residential/ agricultural setting)	10-20	-	600	25	130	-	-
Note: * Cr (VI) is only likely to be present in as a significant proportion of total Cr where pH >12 so this does not routinely need to be tested for regarding plant health.							

CURRENT GUIDANCE FOR CONTROLLED WATERS RISK ASSESSMENT

Summary of Regulatory Context

Government policy is based upon a "suitable for use approach," which is relevant to both the current use of land and also to any proposed future use. When considering the current use of land, Part IIA of the Environment Protection Act 1990 [4] (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995 [5], which came into force in England on 1 April 2000. The main objective of introducing the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health, controlled waters or the wider environment given the current use and circumstances of the land. Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

> *"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:*
>
> *(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or*
> *(b) Pollution of controlled waters is being, or is likely to be, caused."*

Part IIA provides a statutory definition of the pollution of controlled waters under Section 78A(9) as:

> *"the entry into controlled waters of **any** poisonous, noxious or polluting matter or **any** solid waste matter"*

Part IIA is supported by a substantial quantity of guidance and other Regulations, especially for England, The Contaminated Land (England) (Amendment) Regulations 2012 and Contaminated Land Statutory Guidance (DEFRA, 2012) which came into force in early April 2012. The document re-confirms the duties of Enforcing Authorities in dealing with contamination including the role of the Environment Agency which has powers under Part 7 of The Water Resources Act (1991) to take action to prevent or remedy the pollution of controlled waters, including circumstances where the pollution arises from contamination in the land.

Part IIA introduces the concept of a contaminant linkage; where for potential harm to exist there must be a connection between the source of the hazard and the receptor via a pathway. Risk assessment in contaminated land is therefore directed towards identifying the contaminants, pathways and receptors that can provide contaminant linkages. This is known as the contaminant-pathway-receptor link (CPR or contaminant linkage).

Part IIA places contaminated land responsibility as a part of the planning and redevelopment process rather than Local Authority or Environment Agency taking direct action except in situations of very high pollution risk or where harm is occurring. In the planning process guidance is provided by National Planning Policy Framework (NPPF) of March 2012. This requires that a site which has been developed shall not be capable of being

determined "contaminated land" under Part IIA. Therefore, appropriate risk-based investigation is required to identify the contaminant linkages that can then be assessed, and then mitigated using methods that can be readily agreed with the local planning authority.

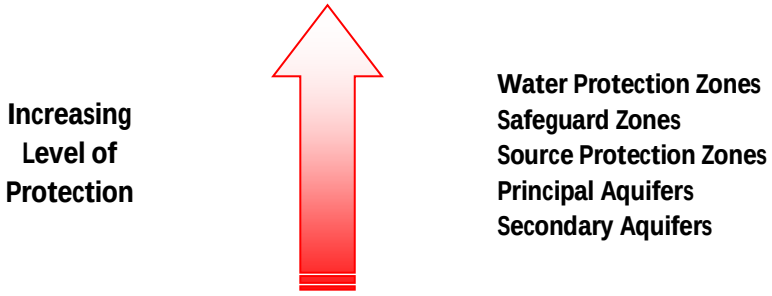
Environment Agency Guidance

Legislation and guidance surrounding the protection of controlled waters in the UK is numerous and can be complex. The Environment Agency's overall position on groundwater is *"To protect and manage groundwater resources for present and future generation in ways that are appropriate for the risks that we identify"* (Groundwater Protection : Policy and Practice GP3, 2012). In brief, the core objectives of the existing legislation serve to enforce this position.

In 1992, the National Rivers Authority published their Policy and Practice for the Protection of Groundwater (PPPG), this document was influential as it provided a focus for key developments such as Source Protection Zones (SPZs) and Groundwater Vulnerability Maps. The Policy was then revised in 1998, since which there have been substantial changes in legislation, driven by Europe. Key European Directives relating to groundwater include the Groundwater Directive (80/68/EEC) and the Water Framework Directive (2000/60/EC). Aspects of these directives are controlled by primary UK legislation such as the Water Resources Act 1991 as amended by the Water Act 2003. Further to legislative changes, gaps identified in the 1998 PPPG required addressing. These changes are reflected in the Environment Agency Policy document *Groundwater Protection: Policy and Practice (GP3), Version 1* of November 2012. The following diagram indicates the three main parts of GP3:

Structure of GP3

The Environment Agency follows a tiered, risk based approach to drinking water protection and this should be taken into account when carrying out controlled waters risk assessment:



Tools available for Risk Assessment of Controlled Waters

In order for a developer of a potentially contaminated site to fulfil their obligations under the legislation, a site assessment would be required to be undertaken in order to identify any potential risks to controlled waters and to derive suitable clean-up criteria if necessary to ensure the protection of controlled waters. A number of tools are available for this purpose and the general approach is detailed further in Part 3 of GP3.

Three main stages apply to any risk assessment of controlled waters, these are:

i) Risk Screening (devise Conceptual Site Model, making reference to groundwater vulnerability maps, site setting etc)
ii) Generic Risk Assessment (using the EA Remedial Targets Methodology – Tier 1 - Comparison of groundwater data with relevant standards)
iii) Detailed Quantitative Risk Assessment (Consideration of aquifer properties and site specific parameters, using the EA Remedial Targets Methodology - Tiers 2 & 3)

The process is summarised below (Taken from the Environment Agency GP3 draft consultation document, 2006):

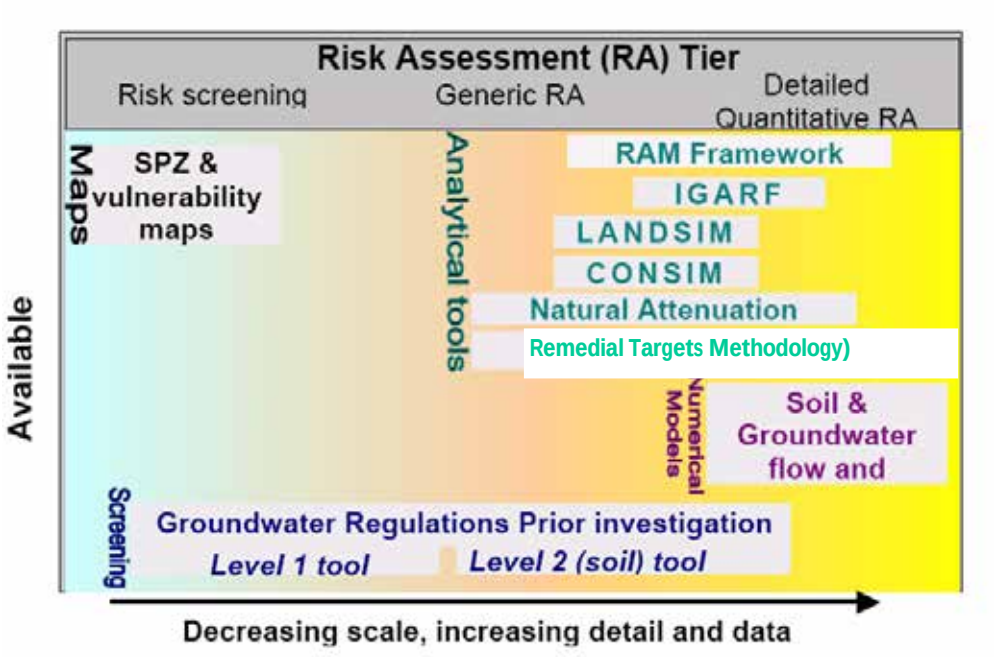


Figure 1-1 Environment Agency groundwater assessment tools, mapped against the different levels of risk assessment.

When assessing groundwater impact the Environment Agency advocate the application of their framework methodology "Remedial Targets Methodology – Hydrogeological Risk Assessment for Land Contamination" Environment Agency (2006). The methodology has four tiers of assessment:

Tier 1 utilises either a soil concentration (calculation of pore water concentrations based on partitioning calculations), leaching test or pore-water concentration of perched water as a source concentration input and these are contrasted directly to water quality standards. No dilution or attenuation is considered at Level 1.

Tier 2 (groundwater) considers dilution of the contaminant within the underlying receiving groundwater or surface water body. To determine a dilution factor the infiltration rate of pore water and the discharge of groundwater beneath the source must be determined. Level 2 Assessment is comprises a comparison between measured groundwater concentrations with to water quality standards.

Tier 3 considers natural attenuation in the form of dispersion, retardation and degradation of the contaminant. As the levels are progressed, the assessment becomes increasingly more detailed and less conservative as the data requirements are increased with each successive tier. The Environment Agency has released Excel Worksheets to carry out basic calculations using a conservative approach up to Tier 3. However, in this case the conceptual model is a simple one and assumes there is a simple migration of contaminants from the source zone into the aquifer receptor. Using these worksheets requires a sensitivity analysis showing how by varying each parameter, what effect it might have on the outcome of the assessment. Groundwater conceptual models are not always this simple.

Tier 4 is for more complex conceptual models where multiple sources, multiple pathways, multiple receptors and complex water balances can be assessed.

The Environment Agency developed a spreadsheet based code to support the Remedial Target Methodology, and the code is capable of undertaking assessments for Tiers 1 to 3. Tier 4 assessment is not supported by the spreadsheet based code.

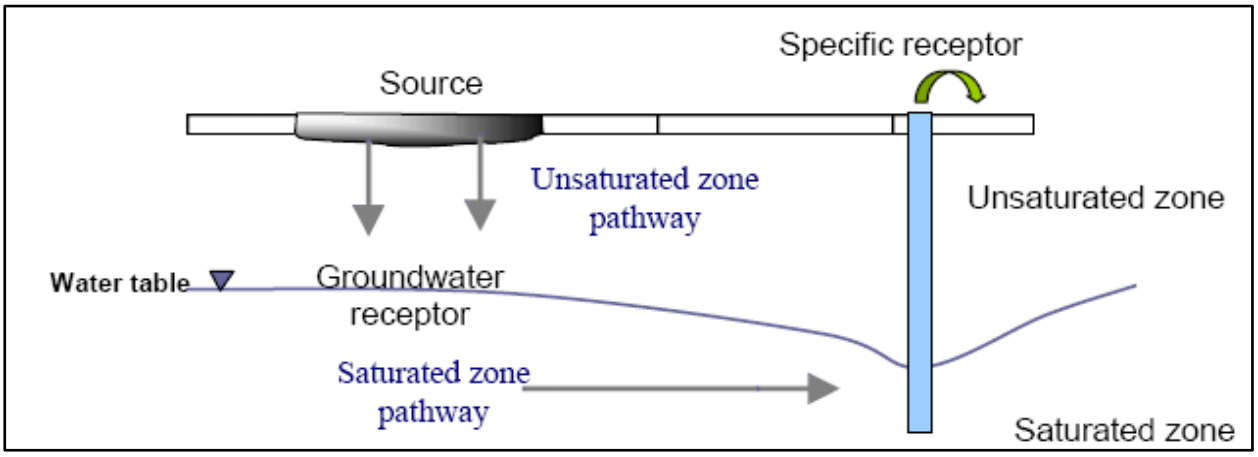
A more advanced code, ConSim 2, developed on behalf of the Environment Agency to support the Remedial Targets Methodology, allows for the introduction of additional geological horizons and is used mainly to determine the concentrations reaching a receptor and the timescales over which this may happen.

The codes assess only the dissolved phase contaminants. There are many further codes commercially available for use in controlled waters risk assessment, particularly for more complex situations, however, these should be used with caution and only once agreement has been obtained from the Environment Agency. All have the overall aim of the estimation of risk from contaminant linkages and the protection of controlled waters.

General notes on each stage of the controlled waters risk assessment process

Risk Screening

The understanding of the Conceptual Site Model (CSM) is the key to assessing any site. Using a robust CSM, potential pathways or receptors may be screened out from any further assessment at an early stage. For example if the pathway through the unsaturated zone is blocked by the presence of a significant thickness of low permeability clay. A greater understanding of the CSM is achieved with each tier of risk assessment. An example of a basic Source-Pathway-Receptor concept is given below (taken from the Environment Agency GP3, 2012):



Generic Risk Assessment

When undertaking the Generic Hydrogeological Risk Assessment (EA Remedial Targets Methodology Tier 1), comparison of chemical analytical results is made with screening criteria. Published values of screening criteria with which chemical test results can be compared are published in the following guidance:
There is a hierarchy of screening criteria which is as follows:

- Updated Recommendations on Environmental Technical Standards, River Basin Management (2015-21), April 2012 by the UK Technical Advisory Group on the Water Framework Directive;
- Environmental Quality Standards (EQS) for freshwaters based on The EC Dangerous Substances Directive (76/464/EEC and Daughter Directives);
- Surface Waters (Abstraction for Drinking Water)(Classification) Regulations (1996)
- Surface Waters (Fishlife) (Classification) Regulations (1997)
- UK Drinking Water Standards (DWS) (Water Supply (Water Quality) Regulations 2000);
- Dutch Ministry of Housing, Spatial Planning and Environment (2001) Intervention Values and Target Values – soil quality standards;
- World Health Organisation Guidelines for Drinking Water (2004)

Should the Level 1 or 2 assessments indicate threshold levels to be exceeded, then there are three alternative ways in which to proceed:

- To devise suitable remedial solutions;
- To carry out more investigation, sampling and analysis;
- To conduct a site-specific Detailed Quantitative Risk Assessment (DQRA) to whether or not the soil materials are suitable for their site-specific intended use or to devise a site-specific clean-up level.

Detailed Quantitative Risk Assessment (DQRA)

The decision to carry out a DQRA will be dependent on the extent and implications of the initial qualitative and generic assessment. The scope of any such assessment will be accurately defined by the outcomes of the former two stages. The CSM will be sufficiently refined by this stage that only certain contaminants of concern, certain pathways and certain receptors will require further assessment, the remainder having been screened out.

Additional site specific data is normally required for this stage of assessment, as explained above, more processes that are capable of affecting contaminant concentrations are considered (such as dilution and attenuation).

Remediation criteria derived will therefore be specific to each site and will be based on a detailed assessment of the potential impact at the identified receptor or *compliance point*. A greater level of confidence can be placed on the predicted impact on the compliance point following a DQRA.

Definition of Controlled Waters

The term 'controlled waters' is defined in Section 104 of the Water Resources Act 1991 as:

> *"Territorial Waters…which extend seawards for three miles…, coastal waters…, inland freshwaters, waters in any relevant lake or pond or of so much of any relevant river or watercourse as is above the freshwater limit, and ground waters, that is to say, any waters contained in underground strata."*

Note that the definition of groundwater under the Water Resources Act 1991 includes all water within underground strata (including soil / pore water in the unsaturated zone). The definition of groundwater under the Groundwater Directive however is limited to water in the saturated zone. For the purposes of Part IIA of the Environmental Protection Act 1990, the Environment Agency recommends that the groundwater within the saturated zone only is considered as the receptor (rather than soil / pore water).

Environment Agency's Aquifer Designations

The Environment Agency have classified different types of aquifer from which groundwater can be extracted. The aquifer designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey.

The maps are split into two different types of aquifer designation:

- **Superficial (Drift)** – permeable unconsolidated (loose) deposits.
- **Bedrock (Solid)**– solid permeable formations e.g. sandstone, chalk, limestone.

The aquifer designations displayed on the Environment Agency maps are as follows:

- **Principal Aquifers (formerly termed Major Aquifers) –** These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as a major aquifer.
- **Secondary Aquifers (formerly termed Minor Aquifers) –** These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:
  - **Secondary A** - 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;
  - **Secondary B** - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
  - **Secondary Undifferentiated** - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
- **Unproductive Strata (formerly termed Non-Aquifer) –** These are rock layers or drift deposits with

low permeability that have negligible significance for water supply or river base flow.

Hazardous and Non Hazardous Substances

The Groundwater (England and Wales) Regulations 2009 control the disposal to the hydrogeological environment of potentially polluting substances which are divided into Hazardous Substances and Non-hazardous Contaminants (this roughly approximates to the former List 1 and List 2 substances).

Hazardous Substances are the most damaging and toxic and must be prevented from directly or indirectly entering the groundwater environment. Hazardous Substances include mineral oils and hydrocarbons, pesticides, biocides, herbicides, solvents and some metals. Discharge of Hazardous Substances to Controlled Waters must be prevented.

Non-hazardous Pollutants are any contaminants other than Hazardous Substances. Non-hazardous Pollutants are potentially toxic but are less harmful than Hazardous Substances, but their direct discharge to groundwater is generally not permitted and any indirect discharge to groundwater must be limited and be controlled by technical precautions in order to prevent pollution. Non-hazardous Pollutants include ammonia and nitrites, many metals and fluorides.

MANAGEMENT OF CONTAMINATED LAND

When risk assessment of the site has been completed and this indicates that remedial works are required, the main guidance in managing this process is set out in the DEFRA/EA publication CLR11 (2004) "Model Procedures for the Management of Land Contamination." The stages of managing remediation are as follows:

(a) Options Appraisal and develop Remediation Strategy;
(b) Develop Implementation Plan and Verification Plan;
(c) Remediation, Verification and Monitoring.

The Remediation Strategy sets out the remediation targets, identifies technically feasible remedial solutions and presents an evaluation of the options so that these can be assessed enabling that the most suitable solution is adopted. An outline of the proposed remedial method should be presented. Agreement should be sought of the appropriate statutory bodies for the Remediation Strategy before proceeding to the next stage.

The Implementation Plan is a detailed method statement setting out how the remediation is to be carried out including stating how the site will be managed, welfare procedures, health and safety considerations together with practical measures such as details of temporary works, programme of works, waste management licences and regulatory consents required. Agreement should again be sought of the appropriate statutory bodies for this Plan.

The Verification Plan sets out the requirements for gathering data to demonstrate that the remediation has met the required remediation objectives and criteria. The Verification Plan presents the requirements for a wide range of issues including the level of supervision, sampling and testing regimes for treated materials, waste and imported materials, required monitoring works during and post remediation, how compliance with all licenses and consents will be checked etc. Agreement should again be sought of the appropriate statutory bodies for the Verification Plan. On completion of the remediation a Verification Report should be produced to provide a complete record of all remediation activities on site and the data collected as required in the Verification Plan. The Verification Report should demonstrate that the remediation has met the remedial targets to show that the site is suitable for the proposed use.

ABBREVIATIONS

Terms

AST	Above Ground Storage Tank
BGS	British Geological Survey
BSI	British Standards Institute
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CIEH	Chartered Institute of Environmental Health
CIRIA	Construction Industry Research Association
CLEA	Contaminated Land Exposure Assessment
CSM	Conceptual Site Model
DNAPL	Dense Non-Aqueous Phase Liquid (chlorinated solvents, PCB)
DWS	Drinking Water Standard
EA	Environment Agency
EQS	Environmental Quality Standard
GAC	General Assessment Criteria
GL	Ground Level
GSV	Gas Screening Value
HCV	Health Criteria Value
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel)
ND	Not Detected
LMRL	Lower Method Reporting Limit
NR	Not Recorded
OD	Ordnance Datum
PAH	Poly Aromatic Hydrocarbon
PCB	Poly-Chlorinated Biphenyl
PID	Photo Ionisation Detector
PCSM	Preliminary Conceptual Site Model
SGV	Soil Guideline Value
TPH (CWG)	Total Petroleum Hydrocarbon (Criteria Working Group)
SPT	Standard Penetration Test
SVOC	Semi Volatile Organic Compound
UST	Underground Storage Tank
VCCs	Vibro Concrete Columns
VSCs	Vibro Stone Columns
VOC	Volatile Organic Compound

Units

m	Metres
km	Kilometres
%	Percent
%v/v	Percent volume in air
mb	Milli Bars (atmospheric pressure)
l/hr	Litres per hour
ha	Hectare (10,000 m^2)
µg/l	Micrograms per Litre (parts per billion)
ppb	Parts Per Billion
mg/kg	Milligrams per kilogram (parts per million)
ppm	Parts Per Million
mg/m^3	Milligram per metre cubed
Mg/m^3	Megagram per metre cubed

µg/m^3	Microgram per metre cubed
m bgl	Metres Below Ground Level
m bcl	Metre Below Cover Level
mOD	Metres Above Ordnance Datum (sea level)
kN/m^2	Kilo Newtons per metre squared
kPa	Kilo Pascal – same as kN/m^2
µm	Micro metre

Appendix C

Fieldwork Records

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP1
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
			0.20	0.20	MADE GROUND - Dark brown sand and gravel. Sand and gravel of brick fragments, concrete fragments and road planings.	0.2	D1	
			1.90	1.70	Orange brown / olive green slightly cobbly gravelly sandy CLAY. Gravel was fine to coarse of chalk. Cobbles were subrounded of flint. (LOWESTOFT FORMATION)			
					Trial pit terminated at 1.9m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion.	Sue Slaven
	2. Trial pit sidewalls stable during excavation.	
	3. No groundwater encountered	PAGE 1

TP1

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP2
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
					Gravel ground cover			
			0.50	0.50	MADE GROUND - Dark brown sand and gravel. Sand and gravel of red/yellow brick fragments, chalk and road planings. Occasional fine roots. At 0.5m - land drain	0.4	D1	
			2.10	1.60	Stiff brown slightly cobbly gravelly slightly sandy CLAY. Gravel was of fine to coarse of chalk. Cobbles of flint and chalk. (LOWESTOFT FORMATION) At 0.9m - pockets of orange brown clayey medium sand. Some of which were saturated with water. Water at base - uncertain of origin			
					Trial pit terminated at 2.1m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion.	Sue Slaven
	2. Trial pit sidewalls stable during excavation.	
	3. Perched water encountered within sand pockets.	PAGE 1

TP2








Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP3
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
					Bare soil / concrete cover			
			0.40	0.40	MADE GROUND - Dark brown gravelly sandy clay. Gravel was of fine to coarse red brick fragments and wood fragments.	0.3	D1	
	▼		2.00	1.60	Stiff brown gravelly CLAY. Gravel was fine to coarse of chalk. (LOWESTOFT FORMATION) To 0.9m - pockets of orange brown clayey medium sand. Some of which were saturated with water.			
					Trial pit terminated at 2.0m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls stable during excavation. 3. Perched water encountered within sand pockets.	Sue Slaven PAGE 1

TP3

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP4
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
					Concrete	0.25	D1	
			0.25	0.25	MADE GROUND - Concrete.			
			0.80	0.55	Dark brown slightly gravelly sandy CLAY and dark brown / orange brown gravelly SAND (LOWESTOFT FORMATION)			
			1.95	1.15	Stiff brown gravelly CLAY. Gravel was fine to coarse of chalk and occasional flint. (LOWESTOFT FORMATION) Pockets of orange brown medium sand.			
					Trial pit terminated at 1.95m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls unstable during fieldwork.	Sue Slaven
		PAGE 1

TP4








Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP5
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
			0.15	0.15	MADE GROUND - Dark brown gravelly sand. Gravel was fine to coarse of road planings and occasional red brick fragments.	0.5	D1	
			0.70	0.55	MADE GROUND - Brown chalk fill Pockets of fine sand			
			2.00	1.30	Olive green / brown gravelly sandy CLAY. Gravel was fine to coarse of chalk. (LOWESTOFT FORMATION) Lenses / pockets of orange brown medium sand with wood fragments.			
					Trial pit terminated at 2.0m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls unstable during fieldwork.	Sue Slaven
		PAGE 1

TP5

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP6
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
			0.50	0.50	MADE GROUND - Dark brown sand and gravel. Sand and gravel is of road planings and brick fragments.	0.4	D1	
			0.75	0.25	Light brown slightly gravelly sandy CLAY. Gravel was fine to medium chalk. (LOWESTOFT FORMATION)			
	▼		1.90	1.15	Olive green / dark brown slightly gravelly sandy CLAY. Gravel was fine to coarse of flint. (LOWESTOFT FORMATION) Water at base - uncertain of its origin.			
					Trial pit terminated at 1.9m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls unstable during fieldwork with collapses form 0.8m in one wall and 1.2m in opposite wall.	Sue Slaven
		PAGE 1

TP6

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP7
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
			0.20	0.20	MADE GROUND - Concrete and bare ground.	0.3	D1	
			0.40	0.20	MADE GROUND - Dark brown clayey sandy soil with fine to coarse roots. Sand of brick fragments. At 0.4m - Black cable within clay pipe across trial pit.			
			2.00	1.60	Olive green / brown slightly cobbly gravelly sandy CLAY. Gravel was fine to coarse of chalk. Cobbles of chalk and flint. (LOWESTOFT FORMATION) Few fine pockets of orange brown medium sand. Water at base - uncertain of its origin.			
					Trial pit terminated at 2.0m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls unstable during fieldwork.	Sue Slaven
		PAGE 1

TP7

Sue Slaven

Site:	Land adjacent Jockey's Hall, Combs	Exploratory Hole Reference:
Client:	Graham Gregory	TP8
Project No.	P0055	

Excavation Method:	Dates:	Location Details
3-tonne Mini-Digger	22/02/19 - 25/02/2019	See Sample Location Plan included within Report

Backfill/Install'n	Water strike	Legend	Depth (m)	Thickness (m)	Stratum Description	Sampling		
						Depth m	Type & No	Results
					Grass cover	0.3	D1	
			0.20	0.20	Dark brown slightly gravelly sandy clayey TOPSOIL.			
				1.90	Light brown / olive green cobbly very gravelly very sandy CLAY. Sand was orange brown and medium. Gravel and cobbles of chalk and flint. (LOWESTOFT FORMATION)			
	▼		2.10		Water at base - its origin unknown.			
					Trial pit terminated at 2.1m.			

Log issue: 01	Remarks:	Logged by:
Scale: None	1. Trial pit backfilled with arisings on completion. 2. Trial pit sidewalls unstable during fieldwork.	Sue Slaven
		PAGE 1

TP8

Appendix D

Summary of Chemical Testing Data and Laboratory Certificates

SITE: Land adjacent Jockey's Hall, Jockey's Lane, Combs
CHEMICAL STATISTICAL ANALYSIS - based on CLEA v1.06 (Sandy Loam 1% SOM)

Job No: P0029

Determinand	Limit of Detection	SAMPLE REFERENCES								Statistical Analysis					SGV / GAC Statistical Results			SGV / GAC Statistical Results			SGV / GAC Statistical Results			SGV / GAC Criteria Source		pC4SL Screening Criteria		pC4SL Screening Criteria		pC4SL Screening Criteria		pC4SL Criteria Source		LQM/CIEH S4UL Screening Criteria		LQM/CIEH S4UL Screening Criteria		LQM/CIEH S4UL Screening Criteria		LQM/CIEH S4UL Criteria Source	
		TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8																														
		0.2m	0.4m	0.3m	0.25m	0.5m	0.4m	0.3m	0.3m																														
		25-Feb-19	25-Feb-19	25-Feb-19	25-Feb-19	25-Feb-19	25-Feb-19	25-Feb-19	25-Feb-19																														
		Sandy Soil	Sandy Soil	Clay	Clay	Clay	Clay	Clay	Clay	n	Standard Deviation	Minimum	Average	Maximum	Maximum	Residential With Veg. Uptake Tier I Screening Criteria	Pass/ Fail	Maximum	Residential Without Veg. Uptake Tier I Screening Criteria	Pass/ Fail	Maximum	Commercial & Industrial Tier 1 Screening Threshold	Pass/ Fail	Source of Screening Criteria	Source of Toxicological Data	Commercial	Pass / Fail	Residential with Home Grown Produce	Pass / Fail	Residential without Home Grown Produce	Pass / Fail	Source of Screening Criteria	Source of Toxicological Data	Commercial	Pass / Fail	Residential with Home Grown Produce	Pass / Fail	Residential without Home Grown Produce	Pass / Fail	Source of Screening Criteria	Source of Toxicological Data
Metals																																								
Arsenic (total)	2 mg/kg	69	10	12	13	10	13	13	14	8	20.15	10	19	69	69	32	Fail	69	35	Fail	69	635	Pass	SC050021*	SC050021	640	Pass	37	Fail	40	Fail	CLEA v1.06	Defra 2014	640	Pass	37	Fail	40	Fail	CLEA v1.06	LQM/CIEH 2014
Cadmium (total)	0.1 mg/kg	65	0.3	0.3	0.3	0.1	0.3	0.2	0.3	8	22.89	0	9	65	65	10	Fail	65	17.7	Fail	65	230	Pass	SC050021*	SC050021	420	Pass	22	Fail	150	Pass	CLEA v1.06	Defra 2014	190	Pass	11	Fail	85	Pass	CLEA v1.06	LQM/CIEH 2014
Chromium (total) (Ill for S4ULs)	0.5 mg/kg	72	22	27	28	17	23	24	31	8	17.30	17	31	72	72	3010	Pass	72	3010	Pass	72	30400	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	8600	Pass	910	Pass	910	Pass	CLEA v1.06	LQM/CIEH 2014
Copper (total)	2 mg/kg	75	12	14	24	14	18	15	23	8	20.91	12	24	75	75	2330	Pass	75	6200	Pass	75	71700	Pass	CLEA v1.06	LOM 2009	-	-	-	-	-	-	-	-	68000	Pass	2400	Pass	7100	Pass	CLEA v1.06	LQM/CIEH 2014
Lead (total)	2 mg/kg	86	16	15	21	10	26	19	17	8	24.59	10	26	86	86	N/A	-	86	N/A	-	86	N/A	-	-	-	6000	Pass	210	Pass	330	Pass	CLEA v1.06	Defra 2014	-	-	-	-	-	-	-	-
Mercury (total inorganic)	1 mg/kg	1	1	1	1	1	1	1	1	8	0.00	1	1	1	1	170	Pass	1	238	Pass	1	3640	Pass	SC050021*	SC050021	-	-	-	-	-	-	-	-	1100	Pass	40	Pass	56	Pass	CLEA v1.06	LQM/CIEH 2014
Nickel (total)	0.5 mg/kg	71	22	39	39	25	30	25	47	8	16.15	22	37	71	71	N/A	-	71	N/A	-	71	N/A	-	-	-	-	-	-	-	-	-	-	-	980	Pass	180	Pass	180	Pass	CLEA v1.06	LQM/CIEH 2014
Selenium (total)	3 mg/kg	63	3	3	3	3	3	3	3	8	21.21	3	11	63	63	350	Pass	63	595	Pass	63	13000	Pass	SC050021*	SC050021	-	-	-	-	-	-	-	-	120000	Pass	250	Pass	430	Pass	CLEA v1.06	LQM/CIEH 2014
Zinc (total)	2 mg/kg	160	58	62	79	38	75	71	64	8	36.25	38	76	160	160	3740	Pass	160	40300	Pass	160	662000	Pass	CLEA v1.06	LOM 2009	-	-	-	-	-	-	-	-	730000	Pass	3700	Pass	40000	Pass	CLEA v1.06	LQM/CIEH 2014
Inorganic / Organic																																								
Asbestos Screen	Detected?	ND	ND	ND	ND	ND	ND	ND	ND																															
pH Value	pH Units	8	7.6	7.9	7.7	8.1	7.9	7.9	8	8	0.16	7.6	8	8.1	8.1	-	-	8.1	-	-	8.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soil Organic Matter	0.10%	7.4	0.9	0.7	1	0.3	1	1.2	0.7	8	2.34	0.3	2	7.4	7.4	-	-	7.4	-	-	7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphate (2:1)	0.01 e/l	0.05	0.04	0.01	0.05	0.05	0.01	0.01	0.01	8	0.02	0.01	0.03	0.05	0.1	-	-	0.05	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphide	10 mg/kg	14	10	10	10	10	10	10	10	8	1.41	10.00	11	14	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOC	0.10%	4.3	0.5	0.4	0.6	0.2	0.6	0.7	0.4	8	1.36	0.2	1	4.3	4.3	-	-	4.3	-	-	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide (total)	1 mg/kg	1	1	1	1	1	1	1	1	8	0.0	1	1	1	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol (Total Monohydric)	1 mg/kg	1	1	1	1	1	1	1	1	8	0.0	1	1	1	1	210	Pass	1	310	Pass	1	24200	Pass	CLEA v1.06	SC050021	-	-	-	-	-	-	-	-	760	Pass	280	Pass	750	Pass	CLEA v1.06	LQM/CIEH 2014
Moisture Content	0.10%	6.2	17	19	21	17	20	19	21	8	4.83	6.2	18	21	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stone Content	0.10%	50.7	0.2	0.2	11.8	5	0.1	1.8	8	8	17.43	0.1	9	50.7	50.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total and Speciated USEPA16 PAH																																								
Naphthalene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	1.54	Pass	0.3	1.64	Pass	0.30	200	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	190	Pass	2.3	Pass	2.3	Pass	CLEA v1.06	LQM/CIEH 2014
Acenaphthylene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	168	Pass	0.3	1950	Pass	0.30	84000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	83000	Pass	170	Pass	2900	Pass	CLEA v1.06	LQM/CIEH 2014
Acenaphthene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	205	Pass	0.3	2020	Pass	0.30	8500	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	84000	Pass	210	Pass	3000	Pass	CLEA v1.06	LQM/CIEH 2014
Fluorene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	163	Pass	0.3	1850	Pass	0.30	64000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	63000	Pass	170	Pass	2800	Pass	CLEA v1.06	LQM/CIEH 2014
Phenanthrene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.3	0.1	0.1	8	0.09	0.1	0.2	0.3	0.3	92	Pass	0.3	837	Pass	0.30	22000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	22000	Pass	95	Pass	1300	Pass	CLEA v1.06	LQM/CIEH 2014
Anthracene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	2260	Pass	0.3	19800	Pass	0.30	530000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	520000	Pass	2400	Pass	31000	Pass	CLEA v1.06	LQM/CIEH 2014
Fluoranthene	0.1 mg/kg	0.4	0.1	0.1	0.1	0.1	0.7	0.1	0.1	8	0.22	0.1	0.2	0.7	0.7	257	Pass	0.7	972	Pass	0.70	23000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	23000	Pass	280	Pass	1500	Pass	CLEA v1.06	LQM/CIEH 2014
Pyrene	0.1 mg/kg	0.4	0.1	0.1	0.1	0.1	0.5	0.1	0.1	8	0.16	0.1	0.2	0.5	0.5	563	Pass	0.5	2330	Pass	0.50	54400	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	54000	Pass	620	Pass	3700	Pass	CLEA v1.06	LQM/CIEH 2014
Benzo[a]anthracene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.4	0.1	0.1	8	0.12	0.1	0.2	0.4	0.4	3.1	Pass	0.4	3.71	Pass	0.40	92	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	170	Pass	7.2	Pass	11	Pass	CLEA v1.06	LQM/CIEH 2014
Chrysene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.4	0.1	0.1	8	0.12	0.1	0.2	0.4	0.4	6	Pass	0.4	8.84	Pass	0.40	138	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	350	Pass	15	Pass	30	Pass	CLEA v1.06	LQM/CIEH 2014
Benzo(b)fluoranthene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.5	0.1	0.1	8	0.15	0.1	0.2	0.5	0.5	5.6	Pass	0.5	7	Pass	0.50	100	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	44	Pass	2.6	Pass	3.9	Pass	CLEA v1.06	LQM/CIEH 2014
Benzo(k)fluoranthene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.5	0.1	0.1	8	0.15	0.1	0.2	0.5	0.5	8.5	Pass	0.5	10	Pass	0.50	140	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	1200	Pass	77	Pass	110	Pass	CLEA v1.06	LQM/CIEH 2014
Benzo(a)pyrene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.5	0.1	0.1	8	0.15	0.1	0.2	0.5	0.5	0.83	Pass	0.5	1	Pass	0.50	14	Pass	CLEA v1.06	LQM 2009	77	Pass	5.0	Pass	5.3	Pass	CLEA v1.06	Defra 2014	35	Pass	2.2	Pass	3.2	Pass	CLEA v1.06	LQM/CIEH 2014
Indeno(123cd)pyrene	0.1 mg/kg	0.4	0.1	0.1	0.1	0.1	0.3	0.1	0.1	8	0.12	0.1	0.2	0.4	0.4	3.2	Pass	0.4	4.17	Pass	0.40	60	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	500	Pass	27	Pass	45	Pass	CLEA v1.06	LQM/CIEH 2014
Dibenzo(ah)anthracene	0.1 mg/kg	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.07	0.1	0.1	0.3	0.3	0.76	Pass	0.3	0.87	Pass	0.30	13	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	3.5	Pass	0.24	Fail	0.31	Pass	CLEA v1.06	LQM/CIEH 2014
Benzo(ghi)perylene	0.1 mg/kg	0.5	0.1	0.1	0.1	0.1	0.3	0.1	0.1	8	0.15	0.1	0.2	0.5	0.5	44	Pass	0.5	46.8	Pass	0.50	650	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	3900	Pass	320	Pass	360	Pass	CLEA v1.06	LQM/CIEH 2014
Total EPA-16 PAHs	0.1 mg/kg	1.5	0.1	0.1	0.4	0.1	4.4	0.1	0.1	8	1.51	0.1	0.9	4.4	4.4	-	-	4.4	-	-	4.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH (CWG) with MTBE & BTEX																																								
Benzene	0.01 mg/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	8	0.00	0.01	0.01	0.01	0.01	0.078	Pass	0.01	0.266	Pass	0.01	43.6	Pass	CLEA v1.06	SC050021	100	Pass	0.87	Pass	3.3	Pass	CLEA v1.06	Defra 2014	27	Pass	0.087	Pass	0.38	Pass	CLEA v1.06	LQM/CIEH 2014
Toluene	0.01 mg/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	8	0.00	0.01	0.01	0.01	0.01	119	Pass	0.01	607	Pass	0.01	86200	Pass	CLEA v1.06	SC050021	-	-	-	-	-	-	-	-	56000	Pass	130	Pass	880	Pass	CLEA v1.06	LQM/CIEH 2014
Ethyl Benzene	0.01 mg/kg	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	8	0.01	0.01	0.02	0.03	0.03	65.2	Pass	0.03	167	Pass	0.03	25000	Pass	CLEA v1.06	SC050021	-	-	-	-	-	-	-	-	5700	Pass	47	Pass	83	Pass	CLEA v1.06	LQM/CIEH 2014
M/P Xylene	0.01 mg/kg	0.03	0.03	0.01	0.01	0.01	0.03	0.01	0.01	8	0.01	0.01	0.02	0.03	0.03	41.7	Pass	0.03	53.3	Pass	0.03	9,630	Pass	CLEA v1.06	SC050021	-	-	-	-	-	-	-	-	5900	Pass	56	Pass	79	Pass	CLEA v1.06	LQM/CIEH 2014
O Xylene	0.01 mg/kg	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	8	0.01	0.01	0.02	0.03	0.03	45.2	Pass	0.03	59.5	Pass	0.03	10,700	Pass	CLEA v1.06	SC050021	-	-	-	-	-	-	-	-	6600	Pass	60	Pass	88	Pass	CLEA v1.06	LQM/CIEH 2014
Methyl tert-Butyl Ether	0.01 mg/kg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	8	0.00	0.01	0.01	0.01	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH (C5-C6 aliphatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	30	Pass	0.1	30	Pass	0.1	3400	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	3200	Pass	42	Pass	42	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C6-C7 aromatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	65	Pass	0.1	263	Pass	0.1	28000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	26000	Pass	70	Pass	370	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C6-C8 aliohatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	73	Pass	0.1	73	Pass	0.1	8300	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	7800	Pass	100	Pass	100	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C7-C8 aromatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	120	Pass	0.1	607	Pass	0.1	59000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	56000	Pass	130	Pass	860	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C8-C10 aliphatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	19	Pass	0.1	19	Pass	0.1	2100	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	2000	Pass	27	Pass	27	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C8-C10 aromatic)	0.1 mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8	0.00	0.1	0.1	0.1	0.1	27	Pass	0.1	33	Pass	0.1	3700	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	3500	Pass	34	Pass	47	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C10-C12 aliphatic)	2 mg/kg	10	2	2	2	2	2	2	2	8	2.83	2	3	10	10	93	Pass	10	93	Pass	10	10000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	9700	Pass	130	Pass	130	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C10-C12 aromatic)	2 mg/kg	10	2	2	2	2	2	2	2	8	2.83	2	3	10	10	69	Pass	10	177	Pass	10	17000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	16000	Pass	74	Pass	250	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C12-C16 aliphatic)	2 mg/kg	10	2	2	2	2	2	2	2	8	2.83	2	3	10	10	740	Pass	10	745	Pass	10	61000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	59000	Pass	1100	Pass	1100	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C12-C16 aromatic)	2 mg/kg	10	2	2	2	2	3	3	2	8	2.76	2	3	10	10	140	Pass	10	1780	Pass	10	36000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	36000	Pass	140	Pass	1800	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C16-C21 aliphatic)	2 mg/kg	10	2	2	2	2	2	2	2	8	2.83	2	3	10	10	45000	Pass	10	45000	Pass	10	1600000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	160000	Pass	65000	Pass	65000	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C16-C21 aromatic)	2 mg/kg	120	2	2	2	2	3	2	2	8	41.67	2	17	120	120	250	Pass	120	1290	Pass	120	28000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	28000	Pass	260	Pass	1900	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C21-C35 aliphatic)	2 mg/kg	920	2	2	2	2	2	3	2	8	324.51	2	117	920	920	45000	Pass	920	45000	Pass	920	1600000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	160000	Pass	65000	Pass	65000	Pass	CLEA v1.06	LQM/CIEH 2014
TPH (C21-C35 aromatic)	2 mg/kg	1200	3	2	2	2	10	5	2	8	422.96	2	153	1200	1200	890	Fail	1200	1330	Pass	1200	28000	Pass	CLEA v1.06	LQM 2009	-	-	-	-	-	-	-	-	28000	Pass	1100	Fail	1900	Pass	CLEA v1.06	LQM/CIEH 2014

Below Detection Limits.
Exceeded GAC/SGV
Exceeded pC4SL / S4ULs
Assessment criteria for pH, Sulphide and Sulphate are not based on human health. Sulphate criteria assumes DS-1 ACEC classification for concrete.

Notes
1. Generic Qualitative Assessment Criteria have been used where appropriate based on the current CLEA 1.06 Model (default values, sandy loam 1%SOM). Where no CLEA generic guideline value has been calculated no assessment has been made. The results presented show maximum and mean concentrations. This is to provide a reasonable prediction of the range of data rather than to provide any detailed statistical appraisal.
2. Results lower than detection limit are shaded in grey.
3. When the test result is recorded as being less than the detection limit, the result used for the analysis is the detection limit.
4. Cyanide (total)*, in the absence of a GQAC based on current CLEA 1.06 Model, the Atrisk Soil Value for Cyanide (Free) has been used.
5. For metals. where an SGV has been published. this value has been used. Note that the published SGVs do not include the residential without plant uptake scenario. CLEA v1.06 has therefore been used to derive GACs for this scenario. For oreanics. CLEA v1.06 has been used fas the SGV assumes 6% SOMI
6. pC4SL based on adjusted toxicology and exposure assumptions
7. pC4SL for benzene assumes 6% SOM

CONCEPT LIFE SCIENCES
DELIVERING SCIENCE

Concept Life Sciences is a trading name of Concept Life Sciences Analytical & Development Services Limited registered in England and Wales (No 2514788)

Concept Life Sciences

Certificate of Analysis

3 Crittall Drive
Springwood Industrial Estate
Braintree
Essex
CM7 2RT
Tel : 01376 560120
Fax : 01376 552923

Report Number: 805636-1

Date of Report: 12-Mar-2019

Customer: Sue Slaven
33 Windmill Close
Great Cornard
Suffolk
CO10 0FL

Customer Contact: Mrs Sue Slaven

Customer Job Reference: P0055
Customer Purchase Order: P0055
Customer Site Reference: Jockey's Hall, Combs
Date Job Received at Concept: 27-Feb-2019
Date Analysis Started: 28-Feb-2019
Date Analysis Completed: 11-Mar-2019

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Report checked and authorised by :
Mr Simon Wicks
Organic Section Head

Issued by :
Aislinn Arthey
Customer Service Advisor

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
Mini Suite

				Concept Reference	**805636 001**	**805636 002**	**805636 003**	**805636 004**	**805636 005**
				Customer Sample Reference	**TP1 @ 0.20m**	**TP2 @ 0.40m**	**TP3 @ 0.30m**	**TP4 @ 0.25m**	**TP5 @ 0.50m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Sandy Soil**	**Sandy Soil**	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**					
Arsenic	T257	A40	2	mg/kg	**69**	**10**	**12**	**13**	**10**
Cadmium	T257	A40	0.1	mg/kg	**65**	**0.3**	**0.3**	**0.3**	<0.1
Chromium	T257	A40	0.5	mg/kg	**72**	**22**	**27**	**28**	**17**
Copper	T257	A40	2	mg/kg	**75**	**12**	**14**	**24**	**14**
Lead	T257	A40	2	mg/kg	**86**	**16**	**15**	**21**	**10**
Mercury	T245	A40	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel	T257	A40	0.5	mg/kg	**71**	**22**	**39**	**39**	**25**
Selenium	T257	A40	3	mg/kg	**63**	<3	<3	<3	<3
Zinc	T257	A40	2	mg/kg	**160**	**58**	**62**	**79**	**38**
Asbestos ID	T27	A40			Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected	Asbestos not detected
pH	T7	A40			**8.0**	**7.6**	**7.9**	**7.7**	**8.1**
Soil Organic Matter	T287	A40	0.1	%	**7.4**	**0.9**	**0.7**	**1.0**	**0.3**
(Water Soluble) SO4 expressed as SO4	T242	A40	0.01	g/l	**0.05**	**0.04**	**0.01**	**0.05**	**0.05**
Sulphide	T4	A40	10	mg/kg	**14**	<10	<10	<10	<10
Total Organic Carbon	T21	A40	0.1	%	**4.3**	**0.5**	**0.4**	**0.6**	**0.2**
Cyanide(Total)	T921	M105	1	mg/kg	<1	<1	<1	<1	<1
Phenols(Mono)	T921	M105	1	mg/kg	<1	<1	<1	<1	<1
Moisture @105C	T162	AR	0.1	%	**6.2**	**17**	**19**	**21**	**17**
Retained on 2mm	T2	A40	0.1	%	**50.7**	**0.2**	**0.2**	**0.2**	**11.8**

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
Mini Suite

				Concept Reference	**805636 006**	**805636 007**	**805636 008**
				Customer Sample Reference	**TP6 @ 0.40m**	**TP7 @ 0.30m**	**TP8 @ 0.30m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**			
Arsenic	T257	A40	2	mg/kg	**13**	**13**	**14**
Cadmium	T257	A40	0.1	mg/kg	**0.3**	**0.2**	**0.3**
Chromium	T257	A40	0.5	mg/kg	**23**	**24**	**31**
Copper	T257	A40	2	mg/kg	**18**	**15**	**23**
Lead	T257	A40	2	mg/kg	**26**	**19**	**17**
Mercury	T245	A40	1.0	mg/kg	<1.0	<1.0	<1.0
Nickel	T257	A40	0.5	mg/kg	**30**	**25**	**47**
Selenium	T257	A40	3	mg/kg	<3	<3	<3
Zinc	T257	A40	2	mg/kg	**75**	**71**	**64**
Asbestos ID	T27	A40			Asbestos not detected	Asbestos not detected	Asbestos not detected
pH	T7	A40			**7.9**	**7.9**	**8.0**
Soil Organic Matter	T287	A40	0.1	%	**1.0**	**1.2**	**0.7**
(Water Soluble) SO4 expressed as SO4	T242	A40	0.01	g/l	<0.01	<0.01	**0.01**
Sulphide	T4	A40	10	mg/kg	<10	<10	<10
Total Organic Carbon	T21	A40	0.1	%	**0.6**	**0.7**	**0.4**
Cyanide(Total)	T921	M105	1	mg/kg	<1	<1	<1
Phenols(Mono)	T921	M105	1	mg/kg	<1	<1	<1
Moisture @105C	T162	AR	0.1	%	**20**	**19**	**21**
Retained on 2mm	T2	A40	0.1	%	**5.0**	**0.1**	**1.8**

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
Total and Speciated USEPA16 PAH (SE) (MCERTS)

				Concept Reference	**805636 001**	**805636 002**	**805636 003**	**805636 004**	**805636 005**
				Customer Sample Reference	**TP1 @ 0.20m**	**TP2 @ 0.40m**	**TP3 @ 0.30m**	**TP4 @ 0.25m**	**TP5 @ 0.50m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Sandy Soil**	**Sandy Soil**	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**					
Naphthalene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Acenaphthene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Fluorene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Phenanthrene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Anthracene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Fluoranthene	T16	M105	0.1	mg/kg	**0.4**	<0.1	<0.1	**0.1**	<0.1
Pyrene	T16	M105	0.1	mg/kg	**0.4**	<0.1	<0.1	<0.1	<0.1
Benzo(a)Anthracene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Chrysene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Benzo(b)fluoranthene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	**0.1**	<0.1
Benzo(k)fluoranthene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	**0.1**	<0.1
Benzo(a)Pyrene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	**0.1**	<0.1
Indeno(123-cd)Pyrene	T16	M105	0.1	mg/kg	**0.4**	<0.1	<0.1	<0.1	<0.1
Dibenzo(ah)Anthracene	T16	M105	0.1	mg/kg	<0.3[(2)]	<0.1	<0.1	<0.1	<0.1
Benzo(ghi)Perylene	T16	M105	0.1	mg/kg	**0.5**	<0.1	<0.1	<0.1	<0.1
PAH(total)	T16	M105	0.1	mg/kg	**1.5**	<0.1	<0.1	**0.4**	<0.1

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
Total and Speciated USEPA16 PAH (SE) (MCERTS)

				Concept Reference	**805636 006**	**805636 007**	**805636 008**
				Customer Sample Reference	**TP6 @ 0.40m**	**TP7 @ 0.30m**	**TP8 @ 0.30m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**			
Naphthalene	T16	M105	0.1	mg/kg	<0.1	<0.1	<0.1
Acenaphthylene	T16	M105	0.1	mg/kg	<0.1	<0.1	<0.1
Acenaphthene	T16	M105	0.1	mg/kg	<0.1	<0.1	<0.1
Fluorene	T16	M105	0.1	mg/kg	<0.1	<0.1	<0.1
Phenanthrene	T16	M105	0.1	mg/kg	**0.3**	<0.1	<0.1
Anthracene	T16	M105	0.1	mg/kg	<0.1	<0.1	<0.1
Fluoranthene	T16	M105	0.1	mg/kg	**0.7**	**0.1**	<0.1
Pyrene	T16	M105	0.1	mg/kg	**0.5**	<0.1	<0.1
Benzo(a)Anthracene	T16	M105	0.1	mg/kg	**0.4**	<0.1	<0.1
Chrysene	T16	M105	0.1	mg/kg	**0.4**	<0.1	<0.1
Benzo(b)fluoranthene	T16	M105	0.1	mg/kg	**0.5**	<0.1	<0.1
Benzo(k)fluoranthene	T16	M105	0.1	mg/kg	**0.5**	<0.1	<0.1
Benzo(a)Pyrene	T16	M105	0.1	mg/kg	**0.5**	<0.1	<0.1
Indeno(123-cd)Pyrene	T16	M105	0.1	mg/kg	**0.3**	<0.1	<0.1
Dibenzo(ah)Anthracene	T16	M105	0.1	mg/kg	**0.1**	<0.1	<0.1
Benzo(ghi)Perylene	T16	M105	0.1	mg/kg	**0.3**	<0.1	<0.1
PAH(total)	T16	M105	0.1	mg/kg	**4.4**	**0.1**	<0.1

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
TPH (CWG) with MTBE & BTEX SE

				Concept Reference	**805636 001**	**805636 002**	**805636 003**	**805636 004**	**805636 005**
				Customer Sample Reference	**TP1 @ 0.20m**	**TP2 @ 0.40m**	**TP3 @ 0.30m**	**TP4 @ 0.25m**	**TP5 @ 0.50m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Sandy Soil**	**Sandy Soil**	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**					
Benzene	T209	M105	10	µg/kg	<10	<10	<10	<10	<10
Toluene	T209	M105	10	µg/kg	<10	<10	<10	<10	<10
EthylBenzene	T209	M105	10	µg/kg	<30(110,2)	<10	<10	<10	<10
M/P Xylene	T209	M105	10	µg/kg	<30(110,2)	<10	<10	<10	<10
O Xylene	T209	M105	10	µg/kg	<30(110,2)	<10	<10	<10	<10
Methyl tert-Butyl Ether	T209	M105	10	µg/kg	<10	<10	<10	<10	<10
TPH (C5-C6 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C6-C7 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C6-C8 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C7-C8 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C8-C10 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C8-C10 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
TPH (C10-C12 aliphatic)	T219	M105	2	mg/kg	<10(9)	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C10-C12 aromatic)	T219	M105	2	mg/kg	<10(9)	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C12-C16 aliphatic)	T219	M105	2	mg/kg	<10(9)	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C12-C16 aromatic)	T219	M105	2	mg/kg	<10(9)	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C16-C21 aliphatic)	T219	M105	2	mg/kg	<10(9)	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C16-C21 aromatic)	T219	M105	2	mg/kg	**120**	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C21-C35 aliphatic)	T219	M105	2	mg/kg	**920**	<2(13)	<2(13)	<2(13)	<2(13)
TPH (C21-C35 aromatic)	T219	M105	2	mg/kg	**1200**	**3(13)**	<2(13)	**2(13)**	<2(13)

Concept Reference: 805636
Project Site: Jockey's Hall, Combs
Customer Reference: P0055

Soil Analysed as Soil
TPH (CWG) with MTBE & BTEX SE

				Concept Reference	**805636 006**	**805636 007**	**805636 008**
				Customer Sample Reference	**TP6 @ 0.40m**	**TP7 @ 0.30m**	**TP8 @ 0.30m**
				Date Sampled	**25-FEB-2019**	**25-FEB-2019**	**25-FEB-2019**
				Matrix Class	**Clay**	**Clay**	**Clay**
Determinand	**Method**	**Test Sample**	**LOD**	**Units**			
Benzene	T209	M105	10	µg/kg	<10	<10	<10
Toluene	T209	M105	10	µg/kg	<10	<10	<10
EthylBenzene	T209	M105	10	µg/kg	<10	<10	<10
M/P Xylene	T209	M105	10	µg/kg	<10	<10	<10
O Xylene	T209	M105	10	µg/kg	<10	<10	<10
Methyl tert-Butyl Ether	T209	M105	10	µg/kg	<10	<10	<10
TPH (C5-C6 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C6-C7 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C6-C8 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C7-C8 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C8-C10 aliphatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C8-C10 aromatic)	T54	M105	0.10	mg/kg	<0.10	<0.10	<0.10
TPH (C10-C12 aliphatic)	T219	M105	2	mg/kg	<2(13)	<2(13)	<2(13)
TPH (C10-C12 aromatic)	T219	M105	2	mg/kg	<2(13)	<2(13)	<2(13)
TPH (C12-C16 aliphatic)	T219	M105	2	mg/kg	<2(13)	<2(13)	<2(13)
TPH (C12-C16 aromatic)	T219	M105	2	mg/kg	**3(13)**	**3(13)**	<2(13)
TPH (C16-C21 aliphatic)	T219	M105	2	mg/kg	<2(13)	<2(13)	<2(13)
TPH (C16-C21 aromatic)	T219	M105	2	mg/kg	**3(13)**	**2(13)**	<2(13)
TPH (C21-C35 aliphatic)	T219	M105	2	mg/kg	**2(13)**	**3(13)**	<2(13)
TPH (C21-C35 aromatic)	T219	M105	2	mg/kg	**10(13)**	**5(13)**	<2(13)

Index to symbols used in 805636-1

Value	Description
A40	Assisted dried < 40C
AR	As Received
M105	Analysis conducted on an "as received" aliquot. Results are reported on a dry weight basis where moisture content was determined by assisted drying of sample at 105C
2	LOD Raised Due to Matrix Interference
13	Results have been blank corrected.
9	LOD raised due to dilution of sample
110	LOD raised due to low internal standard recovery.
S	Analysis was subcontracted
M	Analysis is MCERTS accredited
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

Notes

Asbestos subcontracted to REC Limited
Retained on 2mm is removed before analysis

Method Index

Value	Description
T245	ICP/OES (Aqua Regia Extraction)
T257	ICP/OES (SIM) (Aqua Regia Extraction)
T7	Probe
T54	GC/MS (Headspace)
T162	Grav (1 Dec) (105 C)
T209	GC/MS (Head Space)(MCERTS)
T2	Grav
T4	Colorimetry
T921	Colorimetry (CF) (MCERT)
T27	PLM
T219	GC/FID (SE)
T242	2:1 Extraction/ICP/OES (TRL 447 T1)
T287	Calc TOC/0.58
T21	OX/IR
T16	GC/MS

Accreditation Summary

Determinand	Method	Test Sample	LOD	Units	Symbol	Concept References
Arsenic	T257	A40	2	mg/kg	M	001-008
Cadmium	T257	A40	0.1	mg/kg	M	001-008
Chromium	T257	A40	0.5	mg/kg	M	001-008
Copper	T257	A40	2	mg/kg	M	001-008
Lead	T257	A40	2	mg/kg	M	001-008
Mercury	T245	A40	1.0	mg/kg	U	001-008
Nickel	T257	A40	0.5	mg/kg	M	001-008
Selenium	T257	A40	3	mg/kg	U	001-008
Zinc	T257	A40	2	mg/kg	M	001-008
Asbestos ID	T27	A40			SU	001-008
pH	T7	A40			M	001-008
Soil Organic Matter	T287	A40	0.1	%	N	001-008
(Water Soluble) SO4 expressed as SO4	T242	A40	0.01	g/l	M	001-008
Sulphide	T4	A40	10	mg/kg	N	001-008
Total Organic Carbon	T21	A40	0.1	%	N	001-008
Cyanide(Total)	T921	M105	1	mg/kg	M	001-008
Phenols(Mono)	T921	M105	1	mg/kg	M	001-008
Moisture @105C	T162	AR	0.1	%	N	001-008
Retained on 2mm	T2	A40	0.1	%	N	001-008
Naphthalene	T16	M105	0.1	mg/kg	U	001-008
Acenaphthylene	T16	M105	0.1	mg/kg	U	001-008
Acenaphthene	T16	M105	0.1	mg/kg	M	001-008
Fluorene	T16	M105	0.1	mg/kg	M	001-008
Phenanthrene	T16	M105	0.1	mg/kg	U	001-008

Determinand	Method	Test Sample	LOD	Units	Symbol	Concept References
Anthracene	T16	M105	0.1	mg/kg	M	001-008
Fluoranthene	T16	M105	0.1	mg/kg	N	001-008
Pyrene	T16	M105	0.1	mg/kg	N	001-008
Benzo(a)Anthracene	T16	M105	0.1	mg/kg	M	001-008
Chrysene	T16	M105	0.1	mg/kg	M	001-008
Benzo(b)fluoranthene	T16	M105	0.1	mg/kg	U	001-008
Benzo(k)fluoranthene	T16	M105	0.1	mg/kg	N	001-008
Benzo(a)Pyrene	T16	M105	0.1	mg/kg	M	001-008
Indeno(123-cd)Pyrene	T16	M105	0.1	mg/kg	M	001-008
Dibenzo(ah)Anthracene	T16	M105	0.1	mg/kg	M	001-008
Benzo(ghi)Perylene	T16	M105	0.1	mg/kg	M	001-008
PAH(total)	T16	M105	0.1	mg/kg	U	001-008
Benzene	T209	M105	10	µg/kg	M	001-008
Toluene	T209	M105	10	µg/kg	M	001-008
EthylBenzene	T209	M105	10	µg/kg	M	001-008
M/P Xylene	T209	M105	10	µg/kg	M	001-008
O Xylene	T209	M105	10	µg/kg	M	001-008
Methyl tert-Butyl Ether	T209	M105	10	µg/kg	M	001-008
TPH (C5-C6 aliphatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C6-C7 aromatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C6-C8 aliphatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C7-C8 aromatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C8-C10 aliphatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C8-C10 aromatic)	T54	M105	0.10	mg/kg	N	001-008
TPH (C10-C12 aliphatic)	T219	M105	2	mg/kg	N	001-008
TPH (C10-C12 aromatic)	T219	M105	2	mg/kg	N	001-008
TPH (C12-C16 aliphatic)	T219	M105	2	mg/kg	N	001-008
TPH (C12-C16 aromatic)	T219	M105	2	mg/kg	N	001-008
TPH (C16-C21 aliphatic)	T219	M105	2	mg/kg	N	001-008
TPH (C16-C21 aromatic)	T219	M105	2	mg/kg	N	001-008
TPH (C21-C35 aliphatic)	T219	M105	2	mg/kg	N	001-008
TPH (C21-C35 aromatic)	T219	M105	2	mg/kg	N	001-008