PHASE I DESK STUDY REPORT FOR LAND AT NEW HEY ROAD, OUTLANE, HD3 3YQ

18-07-05 Revision 1

REPORT STATUS: FINAL

OCTOBER 2018

Prepared for

HD3 Developments Ltd and Hillbrook SSAS

This report has been prepared under the framework of BS EN 9001:2008

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EXECUTIVE SUMMARY

A Phase I Desk Study Report (which includes a preliminarily risk assessment) was required by Kirklees Council under the National Planning Policy Framework (introduced March 2012), and CLR 11. This report is required to support the planning applications for the site. Kirklees Council requires the report to satisfy the National Planning Policy Framework in which it is stated that:

1. "…To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner…"

2. "…sites should also be suitable for their new use taking account of ground conditions, pollution arising from previous uses and any proposals for land remediation..."

3. "…after remediation, as a minimum, the land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990…"

In order to support the planning application for the site, ***HD3 Developments Ltd and Hillbrook SSAS*** commissioned ***Demeter Environmental Ltd*** to undertake a Phase I Desk Study Report (which includes a preliminarily risk assessment) for land at New Hey Road, Outlane, Huddersfield, HD3 3YQ, for the residential redevelopment of the site

The report has been completed to fulfil the requirements of a preliminary risk assessment in accordance with CLR11 "Model Procedures for the Management of Land Contamination", "National Policy Planning Framework" and "Guiding Principles for Land Contamination" and the documents referred to in Appendix A.

These procedures relate to 'past' contamination, and assume that legislative controls such as Pollution Prevention and Control authorisations control current potentially polluting activities. Emphasis is therefore upon historic site use and how this may affect potential future users of the site should the proposed development plans be realised.

The project has been carried out within the existing legislative framework, which is outlined in Appendix B.

It should be noted that the table below only offers a brief summary of the information presented in this report and is for briefing purposes only. Reference should be made to the main report for detailed analysis undertaken.

Table 1: Executive Summary

	SUBJECT		DATA
SITE INFORMATION AND SETTING	Client		HD3 Developments Ltd and Hillbrook SSAS
	Site		Land at New Hey Road
	Site location		New Hey Road, Outlane, Huddersfield, HD3 3YQ
	Proposed development		Residential redevelopment of the site.
	Planning Reference		N/A
	Grid Reference		408830E, 4181170N
	Current Land Use		Commercial building with yard and landscaping
	Access		Via New Hey Road
CONCEPTUAL SITE MODEL	History		Initially (1854) the site formed part of a larger parcel of open land, the site was developed prior to 1930 when a building was identified on the south western corner of the site. The 1933 map identified the structure as two buildings. The building was extended northwards between 1948 and 1955. The 1961 map identified the building as a depot with a building on the eastern boundary, and as a garage on the 1975 map and as a works from 1990 to 2010. Aerial plates from 2002 to 2011 identify what appears to be container storage on the eastern area as well as storage of an unidentified material adjacent to the building (east), which were removed between 2011 and 2016. The October 2008 street level image confirms containers were present on the eastern area of the site and the items stored on the eastern face of the building was plastic barrels / containers and were identified on the August 2012 images.
	Recorded Geology	Drift	No drift present.
		Solid	Millstone Grit Group (mudstone, siltstone and sandstone) of the Namurian Age.
	Radon		The property is in a Radon Affected Area, as between 3% and 5% of properties are above the Action Level. Basic radon protective measures are necessary.
	Hydrology		There are no water bodies within 250m of the site.
	Hydrogeology	Drift	N/A
		Solid	The solid is regarded as a low sensitivity aquifer
	Previous Site Investigation		N/A
	Potential Sources of Contamination		Made Ground / Inert landfill Garage / filling station / depot Bedrock
	Potential Contaminants of Concern		Wide range of contaminants in the made ground VOC's / SVOC's Radon
	Potential Receptors		Human beings (construction workers) Human beings (future residents) Human beings (trespassers / transient users) Human beings (residents of adjacent properties) Property in the form of buildings (on site) Potable water mains (on site) Human beings (future residents)

Table 1 (continued): Executive Summary

PPL ID	AIM(S) / OBJECTIVES(S)	Proposed Further Investigation	Proposed Remediation In Lieu of Site Investigation
2 to 6	To determine if the UST's have been removed and if they have impacted on site soils:	A trial trench will be excavated along the area of the UST's to determine if the tanks are present. If tanks are present then the works will be terminated and continued on removal of the tanks. On completion of the excavations any hydrocarbon impacted soils (based on visual and olfactory evidence as well as PID headspace) will be removed. On completion of the excavations samples of the faces and base(s) of the excavations will be taken and analysed for hydrocarbons (TPHCWG).	Given the potential for mobile contamination remediation in lieu of investigation is not proposed.
2 to 6	To determine if the inspection pit has impacted site soils:	On completion of the removal of the pit any hydrocarbon impacted soils (based on visual and olfactory evidence as well as PID headspace) will be removed. On completion of the excavations samples of the faces and base(s) of the excavations will be taken and analysed for hydrocarbons (TPHCWG).	
2 to 6	To determine if made ground is present on the site and if present, is it impacted by elevated levels of contamination: To determine if the past uses of the site have impacted on site soils:	Based on the size of the site (0.83Ha) it is proposed that an initial exploratory investigation based on a non-targeted sampling grid of 20m, which equates to approximately 21 positions (trial pits). Additional positions will be incorporated into the exploratory investigation if additional information is required to delineate the areas of made ground. Where encountered samples of the made ground will be taken as well as samples of the natural soils form below the made ground natural soils interface. Additional samples will be taken where there is visual or olfactory evidence of contamination. Samples of made ground will be analysed to the suite in Table 15, initially a maximum of 10 samples will be analysed (targeted towards areas of gardens/landscaping), the remaining samples will be subject to chemical analysis if any exceedances are recorded (e.g. all made ground samples will be analysed for lead if exceedances of lead are recorded). Samples of the natural strata will be subject to chemical analysis at the locations where exceedances have been recorded.	
2 to 6	To determine if the site is impacted by ground gases:	Given that the only potential source of ground gases is the landfill on the site it is proposed that the extent, depth and composition of the landfilled materials is ascertained and TOC analysis in line with the CL:AIRE publication RB17 - A Pragmatic Approach to Ground Gas Risk Assessment (2012). On completion of the assessment the requirement for ground gas monitoring / gas protection measures will be determined.	At this juncture the incorporation of gas protection measures in lieu of investigation is not proposed.
7	To determine if the site is impacted by radon	Prior to demolition levels of radon will me measured it the existing building	Basic radon measures will be incorporated into the building design.
This sheet is intended as a summary of the report; it does not provide a definitive analysis and should not be treated as an independent document.			

1.0 INTRODUCTION

1.1 Desk Study Terms of Reference

1.1.1 This report presents the results of a Phase I Desk Study carried out) on land at New Hey Road, Outlane, Huddersfield, HD3 3YQ, performed for ***HD3 Developments Ltd and Hillbrook SSAS***. This report was written in July 2018 and revised in September 2018 and should be read in the light of any subsequent changes in legislation, statutory requirements or industry practices.

1.1.2 The works were carried out in accordance with the standard terms of contract of ***Demeter Environmental Ltd***.

1.1.3 The aim of the report is to support the planning applications for the site (2018/92935 and 2018/92934).

1.1.4 This report has been prepared in accordance to the Demeter Environmental Limited Quality Management System.

1.2 Aims and Objectives of Desk Study

1.2.1 The objectives of the desk study are as follows:

- To provide information on past and current uses of the site and surrounding area and the nature of any hazards and physical constraints;
- To determine the risks associated with hazardous ground gas, including radon;
- To identify current and likely future receptors, potential sources of contamination and likely pathways and any features of immediate concern, including those that could be introduced in the future;
- To provide information on the geology, geochemistry, soil, hydrogeology and hydrology of the site;
- To identify potentially different sub-areas (zones) of a site, based on differing ground conditions; potential contamination; and past, present and future uses;
- To produce an initial conceptual model for the site as a whole and/or for zones within the site;
- To provide information for the preliminary risk assessment;
- To provide data to assist in the design of potential subsequent exploratory and main investigations and to give an early indication of possible remedial requirements;

- To provide information relevant to worker health and safety and to the protection of the environment during field investigations;
- To identify the need to involve regulatory bodies prior to intrusive investigation.

1.2.2 The primary objective of the desk study is to identify potential environmental issues that may represent a constraint to the proposed redevelopment of the site. The findings of this assessment can be used to determine, if required, the scope of a follow on Phase II intrusive site investigation.

1.2.3 The desk top study provides an initial view in respect of the status of the site with regard to:

- The potential impact on the site of interest from surrounding land uses and other environmental factors;
- Potential contamination of the site strata by historical and or current use;
- The potential impact on the wider environment by historical and or current use of the site of interest;
- Potential problems associated with geological features such as faulting, mineral extraction, mining and land instability;
- The location of above-surface features that may affect the proposed redevelopment.

1.2.4 This study includes a review of the available geological, historical and environmental information in order to establish the likely ground conditions at the site. The review is based on the following information:

- Align any report to the requirements of relevant guidance;
- To assess historical activities, referring to past Ordnance Survey maps, at the site with respect to their potential impact on the site environment;
- To characterise the environmental setting of the site, identify migration pathways and vulnerable receptors for contamination originating at the site, focusing on potential soil and groundwater liabilities;
- To assess historical and current surrounding land use, referring to past Ordnance Survey maps, in relation to known or potential off-site contamination issues that may impact the subject property;

- To identify likely ground conditions at the site and the potential geotechnical and environmental constraints to development;
- To establish development abnormals prior to site development;
- Assessment of the potential risks to both on and off site receptors;
- To develop a preliminary conceptual model.

1.2.5 The data collated in this study has been undertaken to allow the construction of a preliminary conceptual model, which represents the potential contaminant linkages that have been identified on the site. This is used as a basis to develop a strategy for an intrusive investigation where required.

1.3 Scope of Desk Study

1.3.1 The scope of work for this report comprises of the following:

- Procurement of Groundsure GeoInsight Report;
- Procurement of Groundsure EnviroInsight Report;
- Procurement of Ordnance Survey maps;
- Review of published geology;
- Review of data available in the public domain (borehole section sheets etc.);
- Site walkover survey;
- Preparation of a preliminarily risk assessment.

1.4 Proposed Development

1.4.1 It is proposed that a number of dwellings are erected on the site. The proposed development pans are given on the Acumen drawings in Appendix G.

1.5 Basis of Risk Assessment

1.5.1 This assessment has been undertaken with due regard to the Environmental Protection Act 1990, associated statutory guidance (NPPF, PAN 33 etc.), 'Guidance for the Safe Development of Housing on Land Affected by Contamination', 'CLR 11 (Model Procedures for the Management of Land Contamination)', the Contaminated Land Guidance Documents issued by the Environment Agency and the documents referred to in Appendix A. The methods used follow a risk based approach with the potential risk assessed using the 'Source

– pathway – receptor contaminant linkage concept introduced by the Environmental Protection Act.

1.6 Limitations and Exceptions of this Report

1.6.1 This report was undertaken for ***HD3 Developments Ltd and Hillbrook SSAS*** and as such should not be entrusted to any third party without written permission of ***Demeter Environmental Ltd***.

1.6.2 No other third parties may rely upon, use or reproduce the contents of this report without the written permission of ***Demeter Environmental Ltd***. If any unauthorised third party comes into possession of this report they rely on it at their own risk and the authors do not owe them any duty of care or skill.

1.6.3 Except as otherwise requested by ***HD3 Developments Ltd and Hillbrook SSAS***, ***Demeter Environmental Ltd*** is not obliged and disclaims any obligation to update the report for events taking place after:

a) The date on which this assessment was undertaken;
b) The date on which the final report is delivered.

1.6.4 This report has been compiled from a number of sources, within the time constraints of the programme, which ***Demeter Environmental Ltd*** believes to be trustworthy. However ***Demeter Environmental Ltd*** is unable to guarantee the accuracy of information provided by third parties.

1.6.5 The findings and opinions provided in this document are made in good faith and are based on data provided by third parties (Groundsure, Environment Agency, The Coal Authority, and Regulatory Bodies) and the report should be read in conjunction with the limitations on the document control form. The accuracy of map extracts cannot be guaranteed and it should be recognised that different conditions on /adjacent to the site may have existed between and subsequent to the various map surveys.

1.6.6 This report is prepared and written in the context of the purposes stated above and should not be used in a different context. Furthermore, new information, improved practices and legislation may necessitate an alteration to this report in whole or in part after its submission. Therefore with any change in circumstances or after the expiry of one year from the date of this Report, the report should be referred to ***Demeter Environmental Ltd*** for reappraisal.

1.6.7 The conclusions and recommendations of this report are based on the development described in Clause 1.4, for any other development the report may require revision.

1.6.8 ***Demeter Environmental Ltd*** makes no representation whatsoever concerning the legal significance of its findings or to other legal matters referred to in the following report.

1.6.9 All of the comments and opinions contained in this report, including any conclusions, are based on the information obtained by ***Demeter Environmental Ltd***. The conclusions drawn by ***Demeter Environmental Ltd*** could therefore differ if the information obtained is found to be misrepresentative, inaccurate, or misleading. ***Demeter Environmental Ltd*** reserves the right to amend their conclusions and recommendations in the light of further information that may become available.

1.6.10 The report should be read in its entirety, including all associated drawings and appendices. ***Demeter Environmental Ltd*** cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.

1.6.11 This report does not comprise a geotechnical assessment of the strata underlying the site.

1.6.12 Any borehole data from the British Geological Survey sources is included on the following basis: 'The British Geological Survey accept no responsibility for omissions or misinterpretations of the data from their Data Bank as this may be old or obtained from non-BGS sources and may not represent current interpretation'.

1.6.13 The copyright in this report and other plans and documents prepared by ***Demeter Environmental Ltd*** is owned by them and no such report; plan or document may be reproduced, published or adapted without prior written consent.

1.6.14 Complete copies of this report may be made and distributed by the Client as an expedient way in dealing with matters related to its commission.

1.6.15 Any risks identified in a Phase I Desk Study Report are perceived risks. Actual risks can only be assessed following a physical investigation of the site. ***HD3 Developments Ltd and Hillbrook SSAS*** should be aware that this report is based on information available at the time. Where a site investigation has been undertaken, the ground conditions can only be defined precisely at the exploratory positions, whilst an intermediate positions they can only be inferred. It is possible that factors may vary due to seasonal effects or other climatic effects, and may at times differ from those measured during the investigation. While every attempt is made to assess the likelihood and extent of such variations, conditions may nevertheless exist which are undisclosed by this investigation.

1.6.16 The findings of this report are based on finite information obtained from research and consultations. Demeter Environmental Ltd cannot guarantee the reliability of all such information and the searches should not be considered exhaustive. The findings of the report

may need to be reviewed as any future exploratory investigations progress and in the event that additional archive information becomes available.

1.6.17 Notwithstanding the findings of this study (and any subsequent investigations), if any indication of contaminated soil (visual or olfactory) is encountered at any stage of the development further investigation may be required.

1.6.18 Arboricultural Survey and advice on arboricultural issues are considered to be outside the scope of this report except for their effect on the foundations to the proposed buildings. Where identification of any species is made, especially invasive plants such as Japanese Knotweed, Himalayan Balsam or Giant Hogweed, this should only be considered as a preliminary assessment and subject to confirmation by a professional Arboriculturist. Demeter Environmental Ltd takes no responsibility for failing to identify, or the incorrect identification of, any tree or plant species on site.

1.6.19 Our investigations exclude surveys to identify the presence injurious and invasive weeds. Under the Weeds Act 1959, the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent the spread of injurious weeds. The Weeds Act specifies five Injurious weeds: Common Ragwort, Spear Thistle, Creeping of Field Thistle, Broad-leaved Dock and Curled Dock. The Wildlife and Countryside act 1981 provides the primary controls on the release of non-native species into the wild in Great Britain. It is an offence under section 14(2) of the act to 'plant or otherwise cause to grow in the wild' any plants listed in schedule 9, part II. The only flowering plants currently listed are Japanese Knotweed and Giant Knotweed. The presence of such weeds on site may have considerable effects on the cost / timescale in developing the site.

1.6.20 Good guidance on injurious and invasive weeds is provided on DEFRA and Environment Agency web sites.

1.6.21 Our investigations exclude surveys to identify the presence or indeed absence of asbestos in buildings/infrastructure on site. If asbestos is suspected to be present, we recommend specialists in the identification and control / disposal of asbestos are appointed prior to commencement of any works on site or, if appropriate, purchase of the site. The presence of asbestos on site may have considerable effects on the cost / timescale in developing the site. There is good guidance in relation to Asbestos available on the Health and Safety Executive (HSE) web site.

1.6.22 The scope of this investigation does not include an assessment for the presence of asbestos containing materials within or below the buildings or in associated infrastructure in the

ground at the site. Should there be a requirement under Regulation 4 of the Control of Asbestos at Work Regulations 2002 for any part of the site to be deemed 'non-domestic premises' the duty holders should prepare an asbestos risk management plan and this may require technical survey works as described in the HSE Guidance HSG264.

1.6.23 The Health and Safety at Work Act requires that Employers provide safe places of work for their employees. The Control of Asbestos at Work Regulations (CAWR) place very heavy specific duties on those who commission and carry out work on asbestos containing materials. Construction work that is likely to involve exposure of workers to hazards associated with asbestos in existing buildings will be subject to the Construction (Design and Management) Regulations which impose duties upon Clients, Designers and the Contractors carrying out the work. Other health and safety and welfare regulations place duties on Employers to undertake risk assessments and prepare hazard management plans which, in the case of a building likely to contain asbestos, could involve the commissioning of surveys, hazardous materials location registers and proposals for remedial work.

1.6.24 Whilst a site walkover has been undertaken as part of this report, the survey does not constitute either an asbestos or structural survey and all areas of the site may not have been visited / inspected.

1.6.25 Consideration of occupational health and safety issues are beyond the scope of this report.

1.6.26 All assessments and recommendations should be forwarded to the relevant planning authorities for comment and approval prior to implementation.

1.7 Principal Sources of Information

1.7.1 Documents that were available or have been obtained for reference or obtaining data are given in Appendix A. Further information on data used in this report and dates the data was obtained/accessed is given below:

Table 2: Summary of Information Obtained

Source	Data Provided	Date Obtained / Accessed
Groundsure	Ordnance Survey Maps Groundsure GeoInsight Report Groundsure EnvironInsight Report	25th July 2018 25th July 2018 25th July 2018
Kirklees Council	Planning history	25th July 2018 15th October 218
British Geological Survey	1:50,000 Geological Maps 1:10,000 Geological maps Borehole Section sheets	25th July 2018 25th July 2018 25th July 2018
Environment Agency	Historic Landfill Data (5th April 2016) Authorised Landfills (5th April 2016)	25th July 2018 25th July 2018
MAGIC Database	Nirate Vulnerable Zones Aquifer Details Groundwater vulnerability Water Safeguard Zones Groundwater Source Protection Zone	25th July 2018 25th July 2018 25th July 2018 25th July 2018 25th July 2018
Coal Authority	Interactive Map Viewer Coalfield Plans	25th July 2018 25th July 2018
Google Earth©	Aerial plates	25th July 2018
Google Streetview©	Street level imagery	25th July 2018

2 SITE CONTEXT

2.1 Site Location

2.1.1 The site is located off New Hey Road, the approximate grid reference is 408830E, 418117N, as shown on Drawing 1 and Plate 2 in Appendix G.

2.1.2 The site is located within the administrative jurisdiction of Kirklees Council.

2.2 Site Ownership

2.2.1 The site is within the ownership of two parties, the drawing in Appendix G identifies the land within the ownership of HD3 Developments Ltd and Hillbrook SSAS.

2.3 Site Description & Site Reconnaissance Visit

2.3.1 The aims of the walkover were to determine whether there were any obvious potential sources of contamination, pathways and receptors on or near the site and whether there were any obvious geotechnical difficulties with the site. In addition, access routes into the site were investigated in order to establish the feasibility of further site investigation.

2.3.2 A site walkover survey was undertaken in July 2018 by a consultant from Demeter Environmental Ltd, in general accordance with CLEA CLR 2, on completion of a review of relevant historical and environmental data. The observations of the walkover are presented hereunder:

Table 3: Summary of Walkover Survey

Topic		Discussion
Site Description / Use		The site extended to an area of approximately 0.83Ha and the site topography was approximately level. The site comprised of a single storey commercial building as well as a gravelled area to the east and a rough landscaped area to the north and north east. The area on the southern boundary appeared to have been previously a filling station and evidence of underground storage tanks were noted. The building comprised of three distinct areas, the southern area comprised of offices, the western area comprised of two rooms with an inspection pit in the central building. The third area comprised of the eastern building, a cobbled room with a raised (likely loading) area. The area to the north of the site was overgrown and access was limited, but appeared to be landscaped. The area to the east / northeast of the building was covered by poor quality asphalt with rough grass spread across the area. No evidence of the landfill was noted. There was no visual or olfactory evidence of contamination recorded on the site.
Description of surrounding area		Open land / residential
Surrounding Land Uses	North	Open land
	East	Open land
	South	Open land
	West	Open land / residential
Access		Via New Hey Road
Structures		The western area was occupied by a single storey commercial building
Surfacing		The area within the building was either concrete or cobbled. The northern area appeared to be landscaped and the eastern area was covered by poor quality asphalt.
Made Ground		Based on the walkover survey made ground is likely to be present across the site.
Invasive Species		During the site walkover, we did not notice the presence of any Japanese Knotweed, however this plant can be difficult to identify in the early stages of growth and therefore it is not always possible to identify its presence at certain times of the year. It should be noted that we are not qualified ecologists and as such cannot guarantee the absence of Knotweed or other invasive vegetation. It is recommended that if it is suspected that this species or other similarly invasive plants are present at the site, a specialist contractor should be commissioned to make a detailed assessment.
Storage Tanks		Based on site observations UST's may be present on the southern area of the site, the client indicated that the tanks may have been removed.
Raw Material and Chemical Use and Storage		No evidence of significant raw material or chemical use or storage was observed at the site.
Solid Wastes		No significant observations were made of solid waste storage at the site.
Hazardous and Industrial Wastes		No evidence of significant hazardous and industrial waste storage was observed at the site.
Air Emissions		No significant sources of air emissions were observed at the site.
Asbestos Containing Materials		It is likely that due to the age of the building structures that some possible asbestos containing materials are located within the building fabric across the site. It should be noted that we are not qualified asbestos surveyors and as such cannot guarantee the presence or absence of ACM's.
Spills and Releases		No evidence of any spills or releases of substances which may contain potentially polluting materials was noted at the site.

2.3.3 A plan of the site in its current configuration is presented on Drawing 3 in Appendix G.

2.3.4 Photographs of the site and a photograph key plan are presented in Appendix H.

3 SITE HISTORY

3.1 Historical O.S. Maps, Aerial Plates and Street View Images

3.1.1 The historical usage of both the site and the surrounds has been researched by reference to historical maps (maps presented in Appendix I, Old Maps Online, and National Library of Scotland), street plans, street directories, historical aerial photographs (Google Earth, Britain From Above, historical street level imagery and plates in the public domain. The historical O.S. maps are presented in Appendix I and are summarised hereunder in Table 4.

Table 4: Summary of Review of Historical Maps And Aerial Plates

Area	Summary of Historical Review
Site	Initially (1854) the site formed part of a larger parcel of open land, the site was developed prior to 1930 when a building was identified on the south western corner of the site. The 1933 map identified the structure as two buildings. The building was extended northwards between 1948 and 1955. The 1961 map identified the building as a depot with a building on the eastern boundary, and as a garage on the 1975 map and as a works from 1990 to 2010. Aerial plates from 2002 to 2011 identify what appears to be container storage on the eastern area as well as storage of an unidentified material adjacent to the building (east), which were removed between 2011 and 2016. The October 2008 street level image confirms containers were present on the eastern area of the site and the items stored on the eastern face of the building was plastic barrels / containers and were identified on the August 2012 images.
Area adjacent to the site	Initially the site boundaries were formed by New Hey Road / open land to the south, open land to the east and west and Mulehouse Lane to the north west. By 1907 dwellings formed the south western corner of the site. By 1973 the layout of New Hey Road had changed and the southern boundary was formed by the road. No further significant changes could be discerned.
Area within 100m (250m for in-filled land)	A number of potentially contaminative land uses have been identified on the historical O.S. maps, which are discussed below by order of date. **1893:** Old quarry 240m north east – identified up to the 1975 map an can be identified on the aerial plates.

3.2 Anecdotal Evidence

3.2.1 An internet search revealed an image of the site form 1963 showing the fuel pumps (http://www.kirkleesimages.org.uk/frontend.php?keywords=Ref_No_increment;EQUALS;ke20177&pos=2&action=zoom) accessed 26th July 2018.

3.2.2 The site appears to have been occupied by both Gees Garage and Gees Transport Ltd.

3.3 Archaeological Considerations

3.3.1 No known archaeological considerations have currently been identified.

3.3.2 Archaeological information has not been sought as part of this desk study and has not been identified as an issue by the Client. Some Local Authorities require at least an initial archaeological appraisal for development sites.

3.3.3 Archaeological investigations occasionally reveal ground-related problems from ancient times (prior to the 1st Edition O.S. maps) and can occasionally cause foundation and contamination development hazards.

3.3.4 The Local Authority archaeological officer has not been contacted at this stage.

3.4 Planning Information

3.4.1 A search of on-line planning information held by Kirklees Council was undertaken, two applications for the use of the site for the storage of transmission line equipment and plant were made in 1992.

3.4.2 The pending applications for the subject development were noted in the search on the 15th October 2018**.**

3.4.3 A geotechnical report relating to soakaways was submitted to support the applications, which included the excavation of three trial pits, two of which (SA2 and SA3) were within the footprint of the landfill, the base of the made ground was 1mbgl in SA1, 1.15mbgl on SA2 and the base was not determined in SA3 (the pit was terminated at 2mbgl).

3.5 Previous Reports

3.5.1 Demeter Environmental Limited has no knowledge nor has received any reports relating to the site or the surrounding area.

4 ENVIRONMENTAL SETTING

4.1 Published Geology – 1:10,000 Geological Maps

4.1.1 The documented geology has been ascertained by the examination of British Geological Survey 1:10,000 Sheet and the appropriate geological memoir is summarised hereunder.

4.1.2 Deposits of made ground (artificial deposits) are present on the northern area of the site, deposits of made ground are also present 83m south east and 221m north east.

4.1.3 No drift deposits are recorded to be present on the site.

4.1.4 The solid geology is given as the Millstone Grit Group (mudstone, siltstone and sandstone) of the Namurian Age.

4.2 Published Geology – 1:50,000 Geological Maps

4.2.1 The documented geology has been ascertained by the examination of British Geological Survey 1:50,000 Sheet 77 (Huddersfield) and the appropriate geological memoir is summarised hereunder.

4.2.2 No drift deposits are recorded to be present on the site.

4.2.3 The solid geology is given as the Rossendale Formation (Mudstone And Siltstone) of the Namurian Age.

4.3 Data From The Coal Authority

4.3.1 The Coal Authority interactive map viewer was accessed, the map indicates the site is not within a "Development High Risk Area".

4.3.2 The Development High Risk Area is defined as 'The Development High Risk Area is the part of the coal mining reporting area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations. The combination of features includes mine entries; shallow coal workings (recorded and probable); recorded coal mining related hazards; recorded mine gas sites; fissures and breaklines and previous surface mining sites. New development in this defined area needs to demonstrate that the development will be safe and stable taking full account of former coal mining activities. This area was formally known as the Development Referral Area'.

4.4 Borehole Records

4.4.1 The BGS Borehole map indicates that there is 1No. borehole record available within 50m of the site, which is 25m south east of the site, the borehole section sheets records approximately 1m (3'6") of drift cover over sandstone.

4.5 Geological Information from Previous Reports

4.5.1 A geotechnical report relating to soakaways was submitted to support the applications, which included the excavation of three trial pits, two of which (SA2 and SA3) were within the footprint of the landfill, the base of the made ground was 1mbgl in SA1, 1.15mbgl on SA2 and the base was not determined in SA3 (the pit was terminated at 2mbgl).

4.5.2 Clay was encountered at the base of SA1 and SA2, the depth to bedrock was not recorded.

4.6 Geological Hazards

4.6.1 Potential natural geological hazards which may represent a risk to the proposed development on the site could include the following:

Table 5: Summary of Potential Natural Geological Hazards Identified in the Groundsure© Reports

Potential Hazard	Assessed Risk on the Site			
Radon	The property is in a Radon Affected Area, as between 3% and 5% of properties are above the Action Level. Basic radon protective measures are necessary.			
Background Soil Chemistry	Element	Estimated Geometric Mean (mg/kg)	Residential Threshold(mg/kg)	Industrial / Commercial Threshold (mg/kg)
	Arsenic	15-25	37 (S4UL)	640 (S4UL)
	Cadmium	<1.8	10 (S4UL)	230 (S4UL)
	Chromium	90-120	620 (S4UL)	30,400 (S4UL)
	Nickel	15-30	130 (S4UL)	1,700 (S4UL)
	Lead	100-200	200 (C4SL)	750 (C4SL)

4.7 Review Of Data Obtained From Geology and Ground Stability Groundsure Report

4.7.1 A geology and ground stability report has been procured from Groundsure©, which is presented in Appendix J, and is summarised hereunder. Information of aquifer classification is taken from the Environment Agency website.

Table 6: Summary of Data within Groundsure© Geology and Ground Stability Report

Data	Distance	Comments	Significance
Faults	<50m	No data	-
Historical Surface Ground Workings (Potentially In-filled Land)	<250m	186m NE – cutting 200m to 204m NE - quarry 230m E- cuttings	Potential sources of ground gases
Historical Underground Workings	<250m	No data	-
Current Ground Workings	<250m	No data	-
Historical Mining	<1000m	No data	-

5 HYDROLOGY AND HYDROGEOLOGY

5.1.1 The geological succession underlying the site may be regarded as a series of discrete units in terms of their hydrogeological significance, as illustrated hereunder:

Table 7: Hydrogeological Interpretation

UNIT	PROPERTIES	AQUIFER TYPE	FLOW TYPE	PERMEABILITY
Made Ground	Likely to be generally granular and permeable and will permit vertical and lateral transmission of groundwater. Where underlain by an aquiclude perched groundwater may be present in depressions at the interface.	N/A	N/A	N/A
Rossendale Formation	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 A	Fractured	Low to moderate

5.2 Assessment of Vulnerability of Surface Water Receptors

5.2.1 The sensitivity of the surface water bodies within 250m has been assessed in line with the methodology in Appendix C based on the information presented below:

Table 8: Assessment of Vulnerability of Surface Water Receptors

INFORMATION	DISCUSSION
Are there any Watercourses within 250m of the site?	No
Current Ecological / Chemical Quality	N/A
Predicted Ecological / Chemical Quality	N/A
Are there any current surface water abstractions within 1000m of the site?	No
Is the site within a Surface Water Safeguard Zone? (Environment Agency website)	No
Sensitivity of Surface Water	L2 – very low

5.3 Assessment of Vulnerability of Groundwater

5.3.1 The sensitivity of the underlying groundwater in both the drift deposits and bedrock has been assessed in line with the methodology in Appendix C based on the information presented below.

Table 9: Assessment of Vulnerability of Groundwater in Drift and Solid Deposits

INFORMATION	DISCUSSION - Rossendale Formation
Aquifer Designation	Secondary A
Depth of drift cover	Approximately 1m
Groundwater Vulnerability	Minor Aquifer High
Is Site In A Source Protection Zone?	None within 400m
Are There Any Current Groundwater Abstractions Within 1000m Of The Site?	677m SW – spray irrigation
Are There Any Potable Abstractions Within 1000m Of The Site?	No
Is the site within a Groundwater Safeguard Zone?	No
What Is The Sensitivity Of Watercourses That May Be Fed By Groundwater	L2 – very low
Sensitivity of Groundwater	L1 - low

6 DATA OBTAINED FROM REGULATORY BODIES AND OTHERS

6.1 Data From Groundsure

6.1.1 An Environmental Data Report was procured from Groundsure©. Groundsure© reports contain a broad spectrum of environmental data collated from many sources, including the Environment Agency and the relevant local authority. The report is contained in Appendix J.

6.1.2 Relevant data on potentially contaminative land uses within the report, covering an area within a radius of 50m (250m for landfill and Other Waste Sites) from the site is summarised hereunder:

Table 10: Summary of Groundsure© Environmental Data Report

Data	Distance	Comments	Significance
AUTHORISATIONS, INCIDENTS AND REGISTERS			
Historical Land Use	On Site	Garage	Potential source
	<50m	22m NW – brewery	Potential source
Environmental Permits, Incidents and Registers	On Site	No data	-
	<50m	No data	-
Landfill and Other Waste Sites	On Site	New Hey Road Tip – inert	Potential source
	<250m	No data	-
Current Industrial Sites Data	On Site	Works	Potential source
	<50m	36m S – IVS International (waste collection)	Potential source
Records of Petrol and Fuel Sites	On Site	No data	-
	<50m	No data	-
Underground High Pressure Oil and Gas Pipelines	On Site	No data	-
	<50m	No data	-

6.2 Ecological Designated Sites

6.2.1 Data on ecological designated sites with the Groundsure© report covering an area within a radius of 50m from the site are summarised hereunder:

Table 11: Summary of Groundsure© Environmental Data Report

Data	Distance	Comments
ECOLOGICAL DESIGNATED SITES		
Records of Sites of Special Scientific Interest (SSSI):	<50m	No data
Records of National Nature Reserves (NNR):	<50m	No data
Records of Special Areas of Conservation (SAC):	<50m	No data
Records of Special Protection Areas (SPA):	<50m	No data
Records of RAMSAR Sites:	<50m	No data
Records of Local Nature Reserves (LNR):	<50m	No data
Records of World Heritage Sites:	<50m	No data
Records of Environmentally Sensitive Areas:	<50m	No data
Records of Areas Of Outstanding Natural Beauty (AONB)	<50m	No data
Records of National Parks (NP)	<50m	No data
Records of Ancient Woodland:	<50m	No data

6.2.2 If a full assessment of Environmental or Ecological aspects is required, it is recommended that appropriate specialists be consulted.

7 PRELIMINARY CONCEPTUAL MODEL AND PRELIMINARILY RISK ASSESSMENT

7.1 Introduction

7.1.1 The findings of the desk study have been used to develop a preliminary conceptual model of the site, which identifies potential contaminant linkages. The scope of the model is intended primarily to identify potential impacts to human health and environmental receptors from potential on site and off-site contamination sources. More generalised comments may be included with respect to potential impacts to the wider ecosystem if relevant.

7.1.2 Contaminated land is defined under Section 78A(2) of the Environmental Protection Act 1990 IIA, 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:

- Significant harm is being caused, or there is significant possibility of such harm being caused, or
- Pollution of controlled waters is being or is likely to be caused"

7.1.3 Thus land can be defined as contaminated if it is causing significant harm; or where substances in, on or under the land are polluting a controlled water, or there is a significant risk of this happening.

7.1.4 Current approaches (CLR11- 'Model Procedures for the Management of Land Contamination', Part IIA of the Environmental Protection Act 1990 and the National Planning Policy Framework) to risk assessment of contaminated land suggest the construction of a Preliminary Conceptual Model. The purpose of this model is to define all possible complete contaminant linkages, where the requisite source – pathway – target elements are present, and these elements being defined as:

- a contaminant (source) is a hazardous substance or agent, present at levels that have the potential to cause harm or damage a receptor
- a pathway is the means by or through which a contaminant comes into contact with, or otherwise affects, the receptor
- a receptor (target) is an entity (human being, aquatic environment, flora and fauna etc.) that is vulnerable to the adverse effects of the contaminant

7.1.5 This relationship is termed a "contaminant linkage". It should be recognised that for a health or environmental risk to exist, all three elements of the relationship or linkage must be present, i.e.

- if there is no contaminant, or contaminant present at levels below those considered to be harmful or damaging to a receptor, then there can be no adverse effect on a receptor
- if there is no receptor present that can be adversely affected by a contaminant, no harm or damage can arise

- even where both a contaminant and a receptor are present, no harm or damage will occur if there is no pathway by or through which a linkage between the two can be established

7.1.6 The information collated in the desk study was assessed hereunder to determine the potential contaminant linkage(s) existing on this site, and the likelihood of the linkage being present, allowing the construction of a preliminary conceptual model, as discussed hereunder.

7.2 Assessment of Potential Sources of Contamination

7.2.1 The potential sources of contamination identified in the desk study summarised hereunder:

Table 12: Potential Sources of Contamination

Potential Source of Contamination	Distance to Site	Dates Identified on Historical Maps	Discussion	Probability	Consequence	Risk	Does source warrant further assessment?
Made ground	On site	N/A	Site History: Given that the site has been previously developed it is likely that deposits of made ground will be present on the site. Walkover observations: Whilst made ground was not observed during the walkover survey, hard-standing is present on the site, which will be underlain by sub-base which should be treated as made ground, hence the probability of risk occurring in areas of hard-standing) is regarded as likely.	Likely	Medium – chronic effect on human health	Moderate	Yes
Made ground / Inert landfill	On site	N/A	As part of the site is identified as an inert landfill there is evidence the made ground on the site is in excess of 1m and may be up to 5m thick or has an average thickness of 3m. The gas generation potential is regarded as very low, the risk of lateral migration as negligible and the risk for development on site is regarded as low. Where the SOM is between 5% and 15% the level of risk for on site development is regarded as low to moderate.	Low	Severe – acute risk to human health	Moderate	Yes
Site buildings (garage / works / depot / plant storage), UST's and inspection pit	On site	1933 - 2018	The past uses of the site have the potential to impact site soils.	Likely	Medium – chronic effect on human health	Moderate	Yes
Radon	Underlying bedrock	N/A	The site is in an area which is impacted by elevated levels of radon, the incorporation of basic radon protection measures will break the pathways relating to this source.	Likely	Medium – chronic effect on human health	Moderate	Yes
In-filled quarry	240m north east	1893 - 2016	As there is little drift and there is no evidence the quarry has been in-filled it is not regarded as a credible source of ground gases.	None – not a credible source	Severe – acute risk to human health	None	No
Brewery	22m north west	N/A	The brewery is not regarded as a credible source of contamination.	Unlikely	Medium – chronic effect on human health	Low	No
IVS International	36m south	N/A	Whilst this may impact soils, given the distance to the site, it is unlikely that any credible pathways are present.	Unlikely	Medium – chronic effect on human health	Low	No

7.3 Identification of Potential Receptors

7.3.1 Potential receptors of contamination on this site may be represented as tabulated hereunder:

Table 13: Potential Receptors

ID	POTENTIAL RECEPTOR	IS THE RECEPTOR PRESENT?	JUSTIFICATION
A	Human beings (construction workers)	**Yes**	Will be on site during the construction phase
B	Human beings (future residents)	**Yes**	The proposed development is residential
C	Human beings (future worker occupants)	**No**	
D	Human beings (trespassers / transient users)	**Yes**	May be present on the proposed development
E	Human beings (worker occupants of adjacent properties)	**No**	Commercial buildings do not adjoin the site
F	Human beings (residents of adjacent properties)	**Yes**	Dwellings adjoin the site
G	Designated ecological systems	**No**	None have been identified
H	On site flora and fauna	**No**	No sensitive species have been identified
I	Property in the form of buildings (on site)	**Yes**	The development includes the erection of dwellings/buildings
J	Property in the form of buildings (adjacent)	**No**	No buildings form the site boundaries
K	Property in the form of crops/livestock (on site)	**No**	Will not form part of the development
L	Property in the form of crops/livestock (adjacent)	**No**	None have been identified
M	Potable water mains (on site)	**Yes**	The site will be served by potable water mains
N	Potable water mains (off site)	**No**	It is unlikely that water mains for nearby sites will run through the subject site.
O	Groundwater (underlying aquifer)	**No**	The site is underlain by low sensitivity aquifers
P	Surface water bodies	**No**	No high/moderate sensitivity water bodies within 250m

7.4 Potential Pathways

7.4.1 Taking account of the intended use of the site, the pathways by which the above sources and receptors may be linked may be summarised as follows:

Table 14: Potential Pathways

ID	POTENTIAL RECEPTOR	ASSOCIATED POTENTIAL PATHWAYS	JUSTIFICATION FOR EXCLUSION
A	Human beings (construction workers)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Migration of ground gases through permeable strata / preferential pathways	
B	Human beings (future residents)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Dermal contact with soil / soil dust outdoors Dermal contact with soil dust indoors Ingestion of home-grown produce Ingestion of soil attached to home-grown produce Inhalation of soil dust indoors Inhalation of soil dust outdoors Inhalation of soil vapours indoors Inhalation of soil vapours outdoors Inhalation of water vapours indoors Inhalation of water vapours outdoors Migration of ground gases through permeable strata / preferential pathways	
D	Human beings (trespassers / transient users)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust	
F	Human beings (residents of adjacent properties)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Dermal contact with soil / soil dust outdoors Dermal contact with soil dust indoors Ingestion of home-grown produce Ingestion of soil attached to home-grown produce Inhalation of soil dust indoors Inhalation of soil dust outdoors Inhalation of soil vapours indoors Inhalation of soil vapours outdoors Inhalation of water vapours indoors Inhalation of water vapours outdoors Migration of ground gases through permeable strata / preferential pathways	
I	Property in the form of buildings (on site)	Direct contact with aggressive ground conditions Migration of ground gases through permeable strata / preferential pathways	
M	Potable water mains (on site)	Direct contact with aggressive ground conditions Direct contact with organic contamination	

7.5 Preliminarily Qualitative Risk Assessment

7.5.1 In accordance with the current UK Government of 'suitable for use' approach to the assessment of contaminated land, a preliminarily qualitative risk assessment has been undertaken on the potential contaminant linkages identified above, which considers the magnitude of the potential consequence of the risk occurring, the magnitude of the probability of the risk occurring and provides an overall risk classification.

7.5.2 The following sections discuss all the identified potential on and off site sources which warrant further consideration (see Clause 7.2), pathways and receptors in the context of the proposed development and plausible pollutant linkages which may represent a risk to identified receptors such as human health and/or controlled waters from the data gained from the desk study. At this stage the assessment is qualitative and aimed to determine all pollutant linkages, irrespective of significance or allowing for uncertainty.

7.5.3 The purpose of the PQRA is to:

- Refine and update the conceptual model;
- Confirm the presence of actual pollutant linkages;
- Evaluate potentially unacceptable risks; and
- Provide the basis for the options appraisal when unacceptable risks are identified at the site.

7.5.4 The methodology used in the 2001 CIRIA report C552 – "Contaminated Land Risk Assessment. A Guide to Good Practice' and 'Guidance for the Safe Development of Housing on Land Affected by Contamination' is used here and is discussed in Appendix C.

7.5.5 Based on the above a Preliminarily Conceptual Model (PCM) has been created and is presented in hereunder.

Table 15: Preliminarily Conceptual Model

PPL ID	Source	Pollutant(s)	Receptor(s)	Pathways to Receptor	Probability	Consequence	Risk
1	Made Ground / Inert landfill	Arsenic, asbestos, beryllium, cadmium, chromium (III and VI), copper, cyanide, lead, mercury, molybdenum, nickel, PAH's (USEPA 16) selenium, sulphur, thallium, hydrocarbons (TPHCWG), vanadium, zinc VOC's / SVOC's	Human beings (construction workers)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Migration of ground gases through permeable strata / preferential pathways	Likely	Minor – can be prevented by the use of PPE	Low
2	Garage / filling station / depot		Human beings (future residents)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Dermal contact with soil / soil dust outdoors Dermal contact with soil dust indoors Ingestion of home-grown produce Ingestion of soil attached to home-grown produce Inhalation of soil dust indoors Inhalation of soil dust outdoors Inhalation of soil vapours indoors Inhalation of soil vapours outdoors Inhalation of water vapours indoors Inhalation of water vapours outdoors Migration of ground gases through permeable strata / preferential pathways		Medium – there is a potential for chronic effects to humans	Moderate
3			Human beings (trespassers / transient users)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust		Medium – there is a potential for chronic effects to humans	Moderate
4			Human beings (residents of adjacent properties)	Ingestion of soil / soil dust Dermal contact with soil / soil dust Inhalation of soil dust Dermal contact with soil / soil dust outdoors Dermal contact with soil dust indoors Ingestion of home-grown produce Ingestion of soil attached to home-grown produce Inhalation of soil dust indoors Inhalation of soil dust outdoors Inhalation of soil vapours indoors Inhalation of soil vapours outdoors Inhalation of water vapours indoors Inhalation of water vapours outdoors Migration of ground gases through permeable strata / preferential pathways		Medium – there is a potential for chronic effects to humans	Moderate
5			Property in the form of buildings (on site)	Direct contact with aggressive ground conditions Migration of ground gases through permeable strata / preferential pathways		Mild – significant damage to buildings	Moderate / low
6			Potable water mains (on site)	Direct contact with aggressive ground conditions Direct contact with organic contamination		Medium – ingress of contaminants through plastic potable water pipes	Moderate
7	Bedrock	Radon	Human beings (future residents)	Migration of ground gases through permeable strata / preferential pathways	Likely	Medium – there is a potential for chronic effects to humans	Moderate

7.5.6 The potential significant linkages listed above are based on the available data listed in the sections above and the features noted during the site walkover. Therefore the linkages identified are tentative and subject to the following uncertainties(s):

- Presence of made ground on the site;
- To determine if the UST's have been removed and if the UST's have impacted site soils;
- To determine if the inspection pit has impacted on site soils;
- To determine if the past uses of the site have impacted site soils;
- To determine if a landfill is present on the site, the nature of the deposited wastes and the potential for ground gas generation;

7.5.7 The precautionary principle as discussed in PPS23 (withdrawn) has been applied in the assessment of potential sources, pathways and receptors.

7.5.8 It can be seen that contaminant 2 to 7 require further investigation.

8 RECOMMENDATIONS FOR FURTHER WORKS AND SAMPLING STRATEGY

8.1.1 In accordance with the National Policy Planning Framework, Demeter Environmental consider that sufficient information on the potential for contamination is available in this report to allow the validation of any future planning application by Kirklees Council and for conditional planning approval to be granted. Where the report has proposed further intrusive works and/or remediation such a conditional approval will likely include the conditions requiring a site investigation, risk assessment and implementation plan are undertaken to the satisfaction of Kirklees Council prior to commencement of any development.

8.2 Proposals for Further Works

8.2.1 The proposals to investigate / break the potential contaminant linkages identified above in the PCM are discussed hereunder (in order of risk):

Table 16: Proposed Aims and Scope of Further Works

PPL ID	AIM(S) / OBJECTIVES(S)	Proposed Further Investigation	Proposed Remediation In Lieu of Site Investigation
2 to 6	To determine if the UST's have been removed and if they have impacted on site soils:	A trial trench will be excavated along the area of the UST's to determine if the tanks are present. If tanks are present then the works will be terminated and continued on removal of the tanks. On completion of the excavations any hydrocarbon impacted soils (based on visual and olfactory evidence as well as PID headspace) will be removed. On completion of the excavations samples of the faces and base(s) of the excavations will be taken and analysed for hydrocarbons (TPHCWG).	Given the potential for mobile contamination remediation in lieu of investigation is not proposed.
2 to 6	To determine if the inspection pit has impacted site soils:	On completion of the removal of the pit any hydrocarbon impacted soils (based on visual and olfactory evidence as well as PID headspace) will be removed. On completion of the excavations samples of the faces and base(s) of the excavations will be taken and analysed for hydrocarbons (TPHCWG).	
2 to 6	To determine if made ground is present on the site and if present, is it impacted by elevated levels of contamination: To determine if the past uses of the site have impacted on site soils:	Based on the size of the site (0.83Ha) it is proposed that an initial exploratory investigation based on a non-targeted sampling grid of 20m, which equates to approximately 21 positions (trial pits). Additional positions will be incorporated into the exploratory investigation if additional information is required to delineate the areas of made ground. Where encountered samples of the made ground will be taken as well as samples of the natural soils form below the made ground natural soils interface. Additional samples will be taken where there is visual or olfactory evidence of contamination. Samples of made ground will be analysed to the suite in Table 15, initially a maximum of 10 samples will be analysed (targeted towards areas of gardens/landscaping), the remaining samples will be subject to chemical analysis if any exceedances are recorded (e.g. all made ground samples will be analysed for lead if exceedances of lead are recorded). Samples of the natural strata will be subject to chemical analysis at the locations where exceedances have been recorded.	
2 to 6	To determine if the site is impacted by ground gases:	Given that the only potential source of ground gases is the landfill on the site it is proposed that the extent, depth and composition of the landfilled materials is ascertained and TOC analysis in line with the CL:AIRE publication RB17 - A Pragmatic Approach to Ground Gas Risk Assessment (2012). On completion of the assessment the requirement for ground gas monitoring / gas protection measures will be determined.	At this juncture the incorporation of gas protection measures in lieu of investigation is not proposed.
7	To determine if the site is impacted by radon	Prior to demolition levels of radon will me measured it the existing building	Basic radon measures will be incorporated into the building design.

8.2.2 The proposed sampling strategy and site investigation has been created in line with the guidance in BS5930:2015, BS10175:2011, CLR4 and the EA publication 'Secondary model for the development of appropriate soil sampling strategies for contaminated land'.

8.2.3 The proposed site investigation is presented on Drawing 4 in Appendix G.

8.2.4 If any demolition is to be undertaken on site, consideration of BS 6187 should pre-empt any demolition carried out on site. Care should be taken not to spread any potential contamination to other areas during such an exercise with due consideration to CIRIA paper SP102 Remedial Treatment for Contaminated Land, Decommissioning, Decontamination and Demolition.

8.2.5 Prior to any demolition and redevelopment of the site it may be necessary to undertake a Type 3 Asbestos Survey.

8.2.6 If asbestos is encountered during any demolition works or during the intrusive investigation, it should be removed by a licensed contractor.

8.3 Responsibility of Developer / Landowner

8.3.1 It should be noted that where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

8.4 Management of Unexpected Contamination

8.4.1 It is possible that further contamination may be found at any time during the development. Should such contamination be identified or suspected during the site clearance or ground works, these should be dealt with accordingly.

8.4.2 A number of options are available for handling this material, which include:

- The removal from site and disposal to a suitably licensed tip of all material suspected of being contaminated. The material would need to be classified prior to disposal.

- Short-term storage of the suspected material while undertaking verification testing for potential contamination. The storage area should be a contained area to ensure that contamination does not migrate and affect other areas of the site. Depending upon the amounts of material under consideration, this could be either a skip or a lined area.

- Having a suitably experienced environmental engineer either on-call or with a watching brief for the visual and olfactory assessment of the material, and sampling for verification purposes.

8.5 Liaison With the Local Planning Authority

8.5.1 Prior to the commencement of any site works it is recommended that a copy of this report is forwarded to Kirklees Council, and their approval of the conclusions/recommendations contained in this report is obtained prior to the commencement of any works on the site.

8.5.2 Where this report has recommended remedial measures, the methodology on the validation of the remedial measures should be agreed with Kirklees Council prior to commencement of site works (Phase IIIa Implementation Plan). On completion of the remediation a Phase IIIb completion report will need to be submitted to Kirklees Council in order to demonstrate the site has been suitably remediated. Generic remediation methodologies are presented in Appendix F.

APPENDIX A: REFERENCES

The following documents were available or have been obtained for reference or obtaining data:

Groundsure Report			
BGS Borehole Record Viewer			
The Environmental Protection Act	1990		
The Contaminated Land (Wales) Regulations	2006		
The Contaminated Land (Scotland) Regulations	2000		
The Environment Act	1995		
The Radioactive Contaminated Land (Modifications of Enactments) (England) Regulations	2006		
The Radioactive Contaminated Land (Modifications of Enactments) (Wales) Regulations	2006		
The Radioactive Contaminated Land (Scotland) Regulations	2007		
The Water Resources Act	1991		
The Water Act	2003		
The Water Environment and Water Services (Scotland) Act	2003		
The Water (Northern Ireland) Order	1999		
The Wildlife and Country Act	1981		
The Conservation (Natural Habitats, etc.) Regulations	1994		
The Town and Country Planning Act	1990		
The Town and Country Planning (Scotland) Act	1997		
The Building Control Act	1990		
The Construction Design and Maintenance (CDM) Regulations	2007		
The Control of Substances Hazardous to Health (COSHH) Regulations	2002		
The Factories Act	1961		
The Offices, Shops and Railway Premises Act	1963		
The Health and Safety at Work, etc. Act	1974		
The Pollution Prevention and Control Act	1999		
The Control of Pollution Act 1994 as amended	1994		
The Environmental Damage (Prevention and Remediation) Regulations	2009		
The Environmental Damage (Prevention and Remediation) (Wales) Regulations	2009		
The Environmental Liability (Scotland)	2009		
The Environmental Protection (Duty of Care) Regulations	1991		
The Environmental Permitting (England and Wales) Regulations	2007		
The Pollution Prevention and Control (Scotland) regulations	2000		
Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs)	2013	BS 8576:2013	2013
Good practice on the testing and verification of protection systems for buildings against hazardous ground gases	CIRIA	C735	August 2014
Investigation of Potentially Contaminated Sites	BSI	BS10175:2011+A:2013	2013
Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs)	BSI	BS 8576:2013	2013
Environmental Protection Act 1990: Part 2A - Contaminated Land Statutory Guidance	DEFRA	-	April 2012
Environmental Protection Act 1990: Part 2A – Contaminated Land	DEFRA	Circular 1/2006	September 2006 (withdrawn April 2012)
National Planning Policy Framework	Communities and Local Government	-	27th March 2012
Guiding Principles for Land Contamination	Environment Agency	GPLC1 / GPLC2 / GPLC3	March 2010
Planning and Pollution Control	ODPM	PPS23	November 2004 (withdrawn March 2012)
Circular 22/87: Development of Contaminated Land	Welsh Government	22/87	August 1987
Planning Advice Note PAN 33	Scottish Government	PAN 33	October 2000
Contaminated Land Statutory Guidance for Wales	Welsh Government	WG15450	2012
Explanatory Memorandum to the Contaminated Land	Welsh Government	-	February

(Wales) (Amendment) Regulations 2012 and the draft Contaminated Land Statutory Guidance 2012			2012
NHBC Standards	NHBC	-	2014
Code of Practice for Ground Investigations	BSI	BS5930:2015	July 2015
Technical aspects of site investigations in relation to land contamination	Environment Agency	EA P5-065/TR:2000	2000
Contaminated Land Risk Assessment: A Guide to Good Practice	CIRIA	C552	2001
Secondary model for the development of appropriate soil sampling strategies for contaminated land	Environment Agency	EA P5-066/TR:2000	2000
Remedial Targets Methodology - Hydrogeological Risk assessment for Land Contamination	Environment Agency		2006
The physical properties of the minor aquifers in England and Wales	BGS		2000
A framework for assessing the impact of contaminated land on groundwater and surface water	Department of the Environment	DOE CLR 1	1994
Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part IIA of the Environmental Protection Act 1990.	Environment Agency		May 2002
Guidance on Preliminary site inspection of contaminated land	Department of the Environment	DOE CLR 2	1994
Documentary search on industrial sites	Department of the Environment	DOE CLR 3	1994
Sampling strategies for contaminated land	Department of the Environment	DOE CLR 4	1994
Information systems for land contamination	Department of the Environment	DOE CLR 5	1994
Prioritisation + categorisation procedure for sites which may be contaminated	Department of the Environment	DOE CLR 6	1995
Model Procedures for the Management of Land Contamination	Environment Agency	CLEA CLR 11	September 2004
A quality approach for contaminated land consultancy	Department of the Environment	DOE CLR 12	1997
Human health toxicological assessment of contaminants in soil	Environment Agency	Science Report SC050021/SR2	January 2009
Updated technical background to the CLEA model	Environment Agency	Science Report SC050021/SR3	January 2009
A review of body weight and height data used within the Contaminated Land Exposure Assessment model (CLEA)	Environment Agency	SC050021/ Technical Review 1	2009
Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values	Environment Agency	Science Report SC050021/SR7	2008
The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soil	Environment Agency	Report P5-080/TR3	2005
Review of the Fate and Transport of Selected Contaminants in the Soil Environment	Environment Agency	Draft Technical Report P5-079/TR1	2003
Guidance on Comparing Soil Contamination Data with a Critical Concentration	CL:AIRE/ CIEH		May 2008
Various toxicology reports	Environment Agency / DEFRA	CLR TOX1-24	Various dates
Industry Profiles	DEFRA		Various dates
Radon: guidance on protective measures for new developments	BRE	BRE 211	November 2007
Contaminated Land management manual	LQM	LQM2000	2000
Assessing risks posed by hazardous ground gases to buildings (revised)	CIRIA	CIRIA C665	December 2007
Code of practice for the design of protective measures for methane and carbon dioxide ground gas for new buildings	BSI	BS 8485:2015	2015
Using Soil Guideline Values		Science Report SC050021/SGV Introduction	March 2009
Soil guideline values for inorganic arsenic	Environment Agency	SC050021/ arsenic SGV	May 2009
Soil guideline values for mercury	Environment Agency	SC050021/ mercury SGV	April 2009
Soil guideline values for selenium	Environment Agency	SC050021/ selenium SGV	April 2009
Soil guideline values for benzene	Environment Agency	SC050021/ benzene	April 2009

		SGV	
Soil guideline values for toluene	Environment Agency	SC050021/ toluene SGV	April 2009
Soil guideline values for ethylbenzene	Environment Agency	SC050021/ ethylbenzene SGV	April 2009
Soil guideline values for xylenes	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for inorganic arsenic	Environment Agency	SC050021	May 2009
Supplementary information for the derivation of for mercury	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for selenium	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for benzene	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for toluene	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for ethylbenzene	Environment Agency	SC050021	April 2009
Supplementary information for the derivation of for xylenes	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Inorganic Arsenic	Environment Agency	SC050021/Tox 1	May 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Mercury	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Selenium	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Benzene	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Toluene	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Ethylbenzene	Environment Agency	SC050021	April 2009
Contaminants in soil: updated collation of toxicological data and intake values for humans : Xylenes	Environment Agency	SC050021	April 2009
Reclamation of Contaminated Land	Wiley		2004
Policy and Practice For The Protection of Groundwater	Environment Agency		1999
CIRIA Special Publication 102 - Remedial Treatment for Contaminated Land - Volume II: Decommissioning, Decontamination and Demolition	CIRIA	SP102	January 1995
Guidance on the Safe Development of Housing on Land affected by Contamination	Environment Agency	R&D Publication 66	2008
ProUCL User Guide and Technical Guide	USEPA	-	
Guidance on the assessment of and monitoring of natural attenuation of contaminants in groundwater	Environment Agency	R&D Publication 95	2000
The standard penetration test in insensitive clays and soft rocks	Proceedings of the European Symposium on Penetration Testing in the UK	-	1988
Protection of Workers and the General Public During Development of Contaminated Land	HSE	HSG66	September 1991
Trenching practice. 2nd edition	CIRIA	R97	2001
Desiccation in clay soils	BRE	412	February 1996
Methods of test for soils for civil engineering purposes	BSI	BS1377 (Parts 1 to 9)	1990
Eurocode 7: Geotechnical Design – Part 1: General Rules British	BSI	BS EN 1997-1	2004
Eurocode 7: Geotechnical Design – Part 2: Ground Investigation and Testing	BSI	BS EN 1997-2	2007
Geotechnical investigation and testing. Field testing. Electrical cone and piezocone penetration test	BSI	BS EN ISO 22476-1	2012
Geotechnical Investigation and Testing – Field Testing Part 2: Dynamic Probing	BSI	BS EN ISO 22476-2+A1	2011
Geotechnical Investigation and Testing – Field Testing Part 3: Standard Penetration Test	BSI	BS EN ISO 22476-3+A1	2011
Geotechnical investigation and testing. Field testing- Ménard pressuremeter test	BSI	BS EN ISO 22476-4	2012
Geotechnical investigation and testing. Field testing - Flexible dilatometer test	BSI	BS EN ISO 22476-5	2012
Geotechnical investigation and testing. Field testing - Borehole jack test	BSI	BS EN ISO 22476-7	2012
Geotechnical investigation and testing. Field testing – Flat dilatometer test	BSI	BS EN ISO 22476-11	2006

Geotechnical investigation and testing. Field testing - Mechanical cone penetration test (CPTM)	BSI	BS EN ISO 22476-12	2009
The standard penetration test (SPT): methods and use	CIRIA	R143	1995
Low-rise Buildings on Shrinkable Clay	BRE	BRE Digest 240 and 241	1993
Settlement of structures on clay soils	CIRIA	SP27	1983
Piled foundations in weak rock	CIRIA	R181	1999
Theoretical soil mechanics	Terazaghi	-	1943
Soils for civil engineering purposes	BSI	BS 1337	1990
Groundwater Control – Design and Practice	CIRIA	C515	2000
Trees in relation to design, demolition and construction. Recommendations	BSI	BS 5837	2012
Workmanship on Building Sites	BSI	BS 8000	Various
ICRCL 61/84 Notes on the fire hazards of contaminated land	ICRCL	61/84	1986
Soakaway Design	BRE	Digest 365	1991
Design guidance for road pavement foundations (draft HD 25) (Revision 1)	Highways Agency	Draft HD25	2006
Building Regulations Approved Documents	HM Government	Various	2013

APPENDIX B: LEGISLATIVE CONTEXT

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". When considering the current use of land, Part IIA of the Environment Protection Act 1990 (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995, 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 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:

Significant harm is being caused or there is a significant possibility of such harm being caused; or Pollution of controlled waters is being, or is likely to be, caused."

Harm is defined under section 78A of the Environmental Protection Act as meaning 'harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property'. 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".

Types of harm are related to specific receptors in order to determine whether they can be regarded as "significant harm" or "significant possibility of significant harm', as defined in Clause 4 of the DEFRA publication 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance', which is presented hereunder:

Table 1: Categories Of Significant Harm and Significant Possibility of Significant Harm for Each Receptor

	Type of Receptor	Description of harm to that type of receptor that is to be regarded as:"	
		Significant Harm	**Significant Possibility of Significant Harm**
1	Human beings	Death; life threatening diseases (e.g. cancers); other diseases likely to have serious impacts on health; serious injury; birth defects; and impairment of reproductive functions Physical injury; gastrointestinal disturbances; respiratory tract effects; cardio-vascular effects; central nervous system effects; skin ailments; effects on organs such as the liver or kidneys; or a wide range of other health impacts. Death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. For these purposes, disease is to be taken to mean an unhealthy condition of the body or a part of it and can include, for example, cancer, liver dysfunction or extensive skin ailments. Mental dysfunction is included only insofar as it is attributable to the effects of a pollutant on the body of the person concerned.	-
2	Any ecological system, or living organism forming part of such a system, within a location which is: • a site of special scientific interest (under section 28 of the Wildlife and Countryside Act 1981) • a national nature reserve (under s.35 of the 1981 Act) • a marine nature reserve (under s.36 of the 1981 Act) • an area of special protection for birds (under s.3 of the 1981 Act) • a "European site" within the meaning of regulation 8 of the Conservation of Habitats and Species Regulations 2010 • any habitat or site afforded policy protection under paragraph 6 of Planning Policy Statement (PPS 9) on nature conservation (i.e. candidate Special Areas of Conservation, potential Special Protection Areas and listed Ramsar sites); or • any nature reserve established under section 21 of the National Parks and Access to the Countryside Act 1949. and Access to the Countryside Act 1949.	The following types of harm should be considered to be significant harm: • harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location; or • harm which significantly affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location. In the case of European sites, harm should also be considered to be significant harm if it endangers the favourable conservation status of natural habitats at such locations or species typically found there. In deciding what constitutes such harm, the local authority should have regard to the advice of Natural England and to the requirements of the Conservation of Habitats and Species Regulations 2010.	Conditions would exist for considering that a significant possibility of significant harm exists to a relevant ecological receptor where the local authority considers that: • significant harm of that description is more likely than not to result from the contaminant linkage in question; or • there is a reasonable possibility of significant harm of that description being caused, and if that harm were to occur, it would result in such a degree of damage to features of special interest at the location in question that they would be beyond any practicable possibility of restoration.
3	Property in the form of: • crops, including timber; • produce grown domestically, or on allotments, for consumption; • livestock; • other owned or domesticated animals; • wild animals which are the subject of shooting or fishing rights.	For crops, a substantial diminution in yield or other substantial loss in their value resulting from death, disease or other physical damage. For domestic pets, death, serious disease or serious physical damage. For other property in this category, a substantial loss in its value resulting from death, disease or other serious physical damage. The local authority should regard a substantial loss in value as occurring only when a substantial proportion of the animals or crops are dead or otherwise no longer fit for their intended purpose. Food should be regarded as being no longer fit for purpose when it fails to comply with the provisions of the Food Safety Act 1990. Where a diminution in yield or loss in value is caused by a contaminant linkage, a 20% diminution or loss should be regarded as a benchmark for what constitutes a substantial diminution or loss.	Conditions would exist for considering that a significant possibility of significant harm exists to the relevant types of receptor where the local authority considers that significant harm is more likely than not to result from the contaminant linkage in question, taking into account relevant information for that type of contaminant linkage, particularly in relation to the ecotoxicological effects of the contaminant.
4	Property in the form of buildings. For this purpose, "building" means any structure or erection, and any part of a building including any part below ground level, but does not include plant or machinery comprised in a building, or buried services such as sewers, water pipes or electricity cables.	Structural failure, substantial damage or substantial interference with any right of occupation. The local authority should regard substantial damage or substantial interference as occurring when any part of the building ceases to be capable of being used for the purpose for which it is or was intended. In the case of a scheduled Ancient Monument, substantial damage should also be regarded as occurring when the damage significantly impairs the historic, architectural, traditional, artistic or archaeological interest by reason of which the monument was scheduled.	Conditions would exist for considering that a significant possibility of significant harm exists to the relevant types of receptor where the local authority considers that significant harm is more likely than not to result from the contaminant linkage in question during the expected economic life of the building (or in the case of a scheduled Ancient Monument the foreseeable future), taking into account relevant information for that type of contaminant linkage.

For human beings and controlled waters there are four categories of harm, given hereunder:

Table 2: Categories Of Harm for Human Beings and Controlled Waters

Category	Description of harm to that type of receptor that is to be regarded as:"	
	Human Beings	**Controlled Waters**
1	The local authority should assume that a significant possibility of significant harm exists in any case where it considers there is an unacceptably high probability, supported by robust science based evidence, that significant harm would occur if no action is taken to stop it. For the purposes of this Guidance, these are referred to as "Category 1: Human Health" cases. Land should be deemed to be a Category 1: Human Health case where: (a) the authority is aware that similar land or situations are known, or are strongly suspected on the basis of robust evidence, to have caused such harm before in the United Kingdom or elsewhere; or (b) the authority is aware that similar degrees of exposure (via any medium) to the contaminant(s) in question are known, or strongly suspected on the basis of robust evidence, to have caused such harm before in the United Kingdom or elsewhere; (c) the authority considers that significant harm may already have been caused by contaminants in, on or under the land, and that there is an unacceptable risk that it might continue or occur again if no action is taken. Among other things, the authority may decide to determine the land on these grounds if it considers that it is likely that significant harm is being caused, but it considers either: (i) that there is insufficient evidence to be sure of meeting the "balance of probability" test for demonstrating that significant harm is being caused; or (ii) that the time needed to demonstrate such a level of probability would cause unreasonable delay, cost, or disruption and stress to affected people particularly in cases involving residential properties.	This covers land where the authority considers that there is a strong and compelling case for considering that a significant possibility of significant pollution of controlled waters exists. In particular this would include cases where there is robust science-based evidence for considering that it is likely that high impact pollution (such as the pollution described in paragraph 4.38) would occur if nothing were done to stop it.
2	For land that cannot be placed into Categories 1 or 4, the local authority should decide whether the land should be placed into either: (a) Category 2: Human Health, in which case the land would be capable of being determined as contaminated land on grounds of significant possibility of significant harm to human health; or (b) Category 3: Human Health, in which case the land would not be capable of being determined on such grounds. The local authority should consider this decision in the context of the broad objectives of the regime and of the Government's policy as set out in Section 1. It should also be mindful of the fact that the decision is a positive legal test, meaning that the starting assumption should be that land does not pose a significant possibility of significant harm unless there is reason to consider otherwise. The authority should then, in accordance with paragraphs 4.26 to 4.29 below, decide which of the following two categories the land falls into:	This covers land where: (i) the authority considers that the strength of evidence to put the land into Category 1 does not exist; but (ii) nonetheless, on the basis of the available scientific evidence and expert opinion, the authority considers that the risks posed by the land are of sufficient concern that the land should be considered to pose a significant possibility of significant pollution of controlled waters on a precautionary basis, with all that this might involve (e.g. likely remediation requirements, and the benefits, costs and other impacts of regulatory intervention). Among other things, this category might include land where there is a relatively low likelihood that the most serious types of significant pollution might occur.
3	(a) Category 2: Human Health. Land should be placed into Category 2 if the authority concludes, on the basis that there is a strong case for considering that the risks from the land are of sufficient concern, that the land poses a significant possibility of significant harm, with all that this might involve and having regard to Section 1. Category 2 may include land where there is little or no direct evidence that similar land, situations or levels of exposure have caused harm before, but nonetheless the authority considers on the basis of the available evidence, including expert opinion, that there is a strong case for taking action under Part 2A on a precautionary basis. (b) Category 3: Human Health. Land should be placed into Category 3 if the authority concludes that the strong case described in 4.25(a) does not exist, and therefore the legal test for significant possibility of significant harm is not met. Category 3 may include land where the risks are not low, but nonetheless the authority considers that regulatory intervention under Part 2A is not warranted. This recognises that placing land in Category 3 would not stop others, such as the owner or occupier of the land, from taking action to reduce risks outside of the Part 2A regime if they choose. The authority should consider making available the results of its inspection and risk assessment to the owners/occupiers of Category 3 land.	This covers land where the authority concludes that the risks are such that (whilst the authority and others might prefer they did not exist) the tests set out in Categories 1 and 2 above are not met, and therefore regulatory intervention under Part 2A is not warranted. This category should include land where the authority considers that it is very unlikely that serious pollution would occur; or where there is a low likelihood that less serious types of significant pollution might occur.
4	The local authority should not assume that land poses a significant possibility of significant harm if it considers that there is no risk or that the level of risk posed is low. For the purposes of this Guidance, such land is referred to as a "Category 4: Human Health" case. The authority may decide that the land is a Category 4: Human Health case as soon as it considers it has evidence to this effect, and this may happen at any stage during risk assessment including the early stages. The local authority should consider that the following types of land should be placed into Category 4: Human Health: (a) Land where no relevant contaminant linkage has been established. (b) Land where there are only normal levels of contaminants in soil. (c) Land that has been excluded from the need for further inspection and assessment because contaminant levels do not exceed relevant generic assessment criteria. (d) Land where estimated levels of exposure to contaminants in soil are likely to form only a small proportion of what a receptor might be exposed to anyway through other sources of environmental exposure (e.g. in relation to average estimated national levels of exposure to substances commonly found in the environment, to which receptors are likely to be exposed in the normal course of their lives). The local authority may consider that land other than the types described above should be placed into Category 4: Human Health if following a detailed quantitative risk assessment it is satisfied that the level of risk posed is sufficiently low. Local authorities may decide that particular land apparently matching the descriptions above immediately above poses sufficient risk to human health to fall into Categories other than Category 4. However, such cases are likely to be very unusual and the authority should take particular care to explain why the decision has been taken, and to ensure that it is supported by robust evidence.	This covers land where the authority concludes that there is no risk, or that the level of risk posed is low. In particular, the authority should consider that this is the case where: (a) no contaminant linkage has been established in which controlled waters are the receptor in the linkage; or (b) the possibility only relates to types of pollution described in paragraph 4.40 above (i.e. types of pollution that should not be considered to be significant pollution); or (c) the possibility of water pollution similar to that which might be caused by "background" contamination.

Category 1 or 2 encompass land which is capable of being determined as contaminated land on grounds of significant possibility of significant harm to human health.

The guidance defines what 'normal' levels of contamination is and that a site should not be classified as 'contaminated land'.

'Normal' levels of contamination is defined as:

> (a) The natural presence of contaminants (e.g. caused by soil formation processes and underlying geology) at levels that might reasonably be considered typical in a given area and have not been shown to pose an unacceptable risk to health or the environment.
>
> (b) The presence of contaminants caused by low level diffuse pollution, and common human activity other than specific industrial processes. For example, this would include diffuse pollution caused by historic use of leaded petrol and the presence of benzo(a)pyrene from vehicle exhausts, and the spreading of domestic ash in gardens at levels that might reasonably be considered typical.

The UK regulatory authorities have adopted the widely recognised pollutant linkage concept for assessing risks from land contamination. However, the scenarios under which significant harm may occur are often largely defined by the site conditions and the receptor sensitivity. The concept of suitability for use is adopted to ensure that the risk management process addresses the site-specific conditions and that any remediation undertaken reduces risks to an acceptable level. To meet requirements under Part IIA the site should be suitable for its current use, including use for which a planning permission is already held.

Part IIA of The Environmental Protection Act 1990 is supported by the DEFRA publication of April 2012 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance' (this replaces DETR Circular 06/2006), which 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 the National Planning Policy Framework which requires that a site which has been developed shall not be capable of being determined "contaminated land" under Part IIA.

The criteria for assessing levels of pollutants 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 ensure that contaminated land is made suitable for its current use;

(c) To ensure that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of sustainable development.

These three objectives underlie the "suitable for use" approach to 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 comprises of three elements:

(a) ensuring that land is suitable for its current use

(b) ensuring that land is made suitable for any new use, as planning permission is given for that new use

(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

The mere presence of pollutants 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.

Legislation in Scotland, Northern Ireland and Wales

Northern Ireland

The Northern Ireland Assembly was established as part of the Belfast Agreement and it is the prime source of authority for all devolved/transferred matters (including environment and planning) and has full legislative and executive authority. Devolution powers became the responsibility of the Northern Ireland Assembly on the 2nd December 1999. The Executive was subsequently suspended and Direct Rule restored on the 11th February 2000. Restoration of devolution subsequently took place on 30th May 2000. Twenty-four hour suspensions also took place in August and September 2001.

On the 14th October 2002 the Assembly was again suspended and then formally dissolved on the 28th April 2003. Subsequently the Assembly was restored to a state of suspension following elections in November 2003 with the Assembly finally being restored on 8th May 2007.

The Environment and Heritage Service (EHS) is the largest Agency within the Department of the Environment (DOE NI), one of the eleven Northern Ireland Departments created in 1999. The EHS takes the lead in advising on, and in implementing, the Government's environmental policy and strategy in Northern Ireland.

The Planning Service, another Agency which comes under the umbrella of the DOE NI, is responsible for developing and implementing Government planning policies and development plans in Northern Ireland.

Part 3 of the Waste and Contaminated Land (Northern Ireland) Order 1997 contains the main legal provisions for the introduction of a contaminated land regime in Northern Ireland. The Order was enacted in 1997 but the regime is not yet in operation. The provisions within Part 3 are virtually identical to those provided by part 2A and would establish a regime whereby local authorities are under a duty to investigate and identify contaminated land and identify those responsible for its remediation.

In terms of provision of technical guidance for regulators to assist them in the determination of contaminated land the DOE NI references the DEFRA SGV Task Force and CLEA publications.

The primary legislation governing planning in Northern Ireland is the Planning (Northern Ireland) Order 1991 (as amended). This is backed up by secondary legislation and planning policy, including planning policy statements (PPSs) and area plans. However there is currently no specific PPS addressing development on potentially contaminated land.

Planning applications are determined by the Planning Service with local councils, along with other government departments, acting as consultees to the approval process. Despite the lack of guidance the Planning Service, in considering planning applications for brownfield sites, will impose conditions for site investigation and remediation that broadly mirror the requirements of part 3/Part 2A.

Wales

Both the Environment Protection Act 1990 and the Environment Act 1995 were issued on a UK wide basis, so the same principles of Part 2A legislation are applicable. In July 1997 the UK Government published a white paper outlining proposals for devolution. In Wales a referendum was held in September 1997 and the result led to the Government of Wales Act 1998 being issued thus establishing the National Assembly for Wales (NAW) with powers being transferred on 1st July 1999.

Since this time subordinate legislation has been introduced in Wales that details how the provisions of an Act of Parliament will apply, hence the reason for different effects in Wales to that of England.

The elected Assembly Members effectively delegated their powers for implementation of policies and legislation to the Welsh Assembly Government (WAG). One of the subject areas within WAG is Environment Planning & Countryside, which covers the policies and subordinate legislation relevant to land contamination. The preliminary legislation was The Contaminated Land (Wales) Regulations 2001 Welsh Statutory Instrument 2001 No. 2197 (W.157) which came into force on 1st July 2001. This has now been revoked and replaced by The Contaminated Land (Wales) Regulations 2006 Welsh Statutory Instrument 2006 No. 2989 (W.278) which came into force on 10th December 2006. These include the changes for appeals on Remediation Notices, which are required to be made to NAW. The Radioactive Contaminated Land (Modification of Enactments) (Wales) Regulations 2006 were implemented at the same time.

Current Statutory Guidance relevant to Wales is the 'Contaminated Land Statutory Guidance – 2012' (2012) issued by the Welsh Government. This comprises Guidance previously issued in November 2001 and further guidance to accompany other modifications such as the introduction of radioactivity. The principle regulators of the Part 2A process are Environment Agency Wales and as appropriate the local authority responsible for the site in question. As in England the use of the CLEA v1.06 model and the relevant SGV and TOX reports are applicable in Wales.

In respect of Planning the circular 022/87 (WO) prepared by DETR (Department of Environment, Transport and the Regions) on Development of Contaminated Land remains applicable for outlining the requirements associated with new developments, including change of use. The document states that contamination is a material planning consideration, but is ambiguous in a number of areas. It does however indicate that an investigation will normally be required where the previous history of the site suggests contamination.

Planning Policy Wales (2002) outlines that the physical constraints on the land are to be taken into account at all stages of the planning process and this is in the context of land instability and land contamination. It also explains that LPA's (Local Planning Authorities) should be aware of the requirements of Part 2A and ensure that their policies and decisions are consistent with it. This implies that the methods used in assessing land for Part 2A purposes should be applied within the planning regime. Accordingly the concept of risk assessment as a tool to help direct development on a suitable for use basis is appropriate as in England.

NPPF does not apply in Wales, however it may be referred to as good practice, though this may be open to challenge. In Wales Technical Advice Notes (TAN) are used as Planning Policy Statements and currently there is no TAN applicable to land contamination in Wales. WAG is considering the preparation of a TAN and it is understood that this will look at the suitability of PPS23 for Wales, though no timetable for delivering this has been made.

Land Contamination: A Guide for Developers prepared on behalf of the Welsh Local Government Association, Environment Agency Wales & WAG was issued in July 2006. Whilst this is not statutory guidance, it helps confirm good practice and broadly details the risk assessment process in line with CLR11 (Model Procedures).

Scotland

Since the passing of the Scotland Act and the official convening of the Scottish Parliament and the Scottish Executive on the 1st July 1999 devolved matters, including the environment and planning, have been the responsibility of Scottish Ministers.

There are two regulatory enforcement bodies in Scotland with duties and powers in terms of identification and remediation of contaminated land and development of brownfield sites; Local Authorities and the Scottish Environment Protection Agency (SEPA) which was established in 1996.

The current structure of local government in Scotland was established by the Local Government (Scotland) Act 1994. Since the passing of the Act Scotland has been divided into 29 unitary authorities and 3 island authorities. It is the responsibility of the Scottish Executive to implement Part 2A of the Environmental Protection Act, 1990. Scottish Ministers therefore implemented.

The Contaminated Land (Scotland) Regulations 2000 (SI2000/178) (the 2000 Regulations) with accompanying statutory guidance on the 14th July 2000. The 2000 Regulations were replaced on the 1st April 2006 by the Contaminated Land (Scotland) 2005 Regulations (the 2005 Regulations). The 2005 Regulations amended Part 2A of the Environmental Protection Act 1990 and the 2000 Regulations in the light of the Water Environment and Water Services (Scotland) Act 2003. Guidance on the 2005 Regulations was published in June 2006 in the form of Paper SE/2006/44 (Statutory Guidance; Edition 2) by the Scottish Executive. The document replaces in its entirety the guidance issued July 2000.

Contaminated land was defined in the 2000 Regulations where pollution of controlled waters is being, or is likely to be caused. This meant that any degree of pollution of controlled waters could have resulted in the land being designated as contaminated. The 2005 Regulations addressed the anomaly whereby trivial amounts of pollution resulted in land being designated as contaminated by introducing a requirement that pollution be "significant" or likely to be "significant" in relation to the water environment.

Unlike England and Wales the 2005 Regulations do not include radioactive contamination. The Radioactive Contaminated Land (Scotland) Regulations 2007 came into force in Scotland on the 30th October 2007. The Regulations make provision for Part 2A to have effect with modifications for the purpose of the identification and remediation of radioactive contaminated land.

When brownfield or contaminated sites are being developed, Local Authorities require that the need for remediation is determined using guidance provided by Planning Advice Note (PAN) 33. PAN 33 uses the Suitable for Use Approach. The approach focuses on the risks caused by land contamination and 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.

The Suitable for Use Approach comprises three elements:

- Ensuring that land is suitable for its current use;
- Ensuring that land is made suitable for any new use as planning permission is given for that use; and
- Limiting the 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 for which planning permission is being sought.

APPENDIX C: RISK ASSESSMENT METHODOLOGIES

RISK ASSESSMENT METHODOLOGY

The methods applied by ***DEMETER ENVIRONMENTAL Ltd*** in the assessment of risks to receptors from soil, water and gas data, are presented hereunder:

LEGISLATION OVERVIEW:

The legislative background to risk assessment is discussed in the legislative Appendix B.

RISK ASSESSMENT METHODOLOGY

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 (2000) publication "A Guide to Risk Assessment and Risk Management for Environmental Protection." 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 investigation process the above steps are repeated as more detailed information becomes available for the site.

CLR11- 'Model Procedures for the Management of Land Contamination', a document published by the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) outlines a tiered approach to the assessment of risks posed by contaminated land, as summarised hereunder:

Tier 1: Preliminary Risk Assessment

A Preliminary Risk Assessment is usually undertaken as part of a desk study, outlines potential risks posed by potential contamination to all receptors by defining plausible "pollution linkages" and developing a preliminary conceptual model (PCM). The purpose of this model is to define all possible complete pollution linkages, where the requisite source – pathway – target elements are present, and these elements being defined as:

- a contaminant (source) is a hazardous substance or agent, present at levels that have the potential to cause harm or damage a receptor
- a pathway is the means by or through which a contaminant comes into contact with, or otherwise affects, the receptor
- a receptor (target) is an entity (human being, aquatic environment, flora and fauna etc) that is vulnerable to the adverse effects of the contaminant

This relationship is termed a "pollution linkage". It should be recognised that for a health or environmental risk to exist, all three elements of the relationship or linkage must be present, i.e.

- if there is no contaminant, or contaminant present at levels below those considered to be harmful or damaging to a receptor, then there can be no adverse effect on a receptor
- if there is no receptor present that can be adversely affected by a contaminant, no harm or damage can arise
- even where both a contaminant and a receptor are present, no harm or damage will occur if there is no pathway by or through which a linkage between the two can be established

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

Potential contaminants of concern are identified with the aide of the Environment Agency and NHBC publication 'Guidance for the Safe Development of Housing on Land Affected by Contamination', the Department of Environment Industry Profiles and the now withdrawn CLEA CLR 8, which consolidated the information Industry Profiles into a tabular format.

The PCM is subject to continual refinement as additional data becomes available. As part of a Phase I Investigation (Desk Study and site walk over) a PCM is formed. Based on the PCM, potential pollutant linkages can be assessed. If the PCM and hazard assessment indicate that a pollution linkage is not of significance then no further assessment or action is required due to this linkage. For each significant and possible 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 usually termed a Phase II Main Site Investigation and should provide additional data to allow refinement of the PCM and assess the level of risk from each pollutant linkage. The risk assessment will usually include a Tier 2 Generic Quantitative Risk Assessment and / or, if necessary, a Tier 3 Detailed Quantitative Risk Assessment.

The criteria used for a Tier 1 risk assessment are broadly based on those presented in Section 6.3 of the CIRIA Report 'Contaminated Land Risk Assessment: A Guide to Good Practice' (CIRIA Report C552) and Section 1.7 of Guidance on the Safe Development of Housing on Land affected by Contamination. The consequence of the risk is classified according to the criteria in Table A below:

Assessment of Sensitivity of Water Resources

The criteria used to determine the sensitivity of a water resource is given hereunder:

Groundwater

Sensitivity Assessment	**Standard Response**	**Implications/need for further work (subject to nature of source and pathway)**
H1 (Very high)	Highly vulnerable aquifer, actively used in vicinity of site with short travel times to sources of supply or sensitive watercourses. Likely to be within an inner or outer groundwater protection zone (Zones I or II under EA protection policy). All contaminant releases to the ground environment of concern.	Extensive groundwater and soil clean-up or removal is likely to be needed if a source and pathway exist. Potential for major on-site and off-site liabilities. Further, detailed risk assessment essential and is likely to be required by the Regulators. Could be long-term residual liabilities with major cost implications and potential high risk of prosecution.
H2 (High)	Major or minor vulnerable aquifer with probable use nearby (either direct abstraction or baseflow to sensitive watercourses and springs). Likely to be within Outer or Source Catchment protection zones (Zones II or III). Most contaminant releases to the ground environment of concern.	Significant groundwater remediation measures may be required, after detailed risk assessment, which is likely to be required by the Regulators. Soil decontamination or isolation probably necessary. Potential for significant on-site and off-site liabilities, including treatment and/or replacement of local potable water supplies. Substantial cost implications and potential moderate/high risk of prosecution.
M1 (Moderately high)	Recognised major or minor aquifer, moderately vulnerable, with probable use (either direct or via baseflow to a sensitive watercourse). Within formal protection zone or catchment of authorised abstractions for potable or other high quality uses. Minor, short-term releases of contaminants may be tolerable.	Following risk assessment, soil decontamination or isolation may be required. Localised groundwater clean-up may be needed but large scale clean-up unlikely unless source is substantial and toxic. Possible off-site liabilities such as replacement/treatment of local potable water supplies. Moderate cost implications and potential moderate risk of prosecution.
M2 (Moderate)	Minor aquifer, low to moderately vulnerable, but with possible uses in general area, particularly for domestic supplies. May provide pathway to surface water.	Risk assessment may indicate need for localised clean up/isolation of soil and groundwater only, but may be some off-site liabilities e.g. local potable water supplies. Moderate to low cost implications. Potential prosecution less likely.
L1 (Low)	Permeable strata/minor aquifer near surface, but no apparent use and low vulnerability (may also be a significant aquifer but downgraded by long-term/ permanent degradation of water quality). May provide pathway to surface watercourse at distance.	Localised clean-up/isolation of soil and groundwater only. Unlikely to be significant off-site liabilities or action by statutory authorities with respect to groundwater. Low cost implications.
L2 (Very low)	Not a recognised aquifer, but strata beneath site may retain a small amount of contaminated liquid but there is likely to be limited vertical penetration. High potential for surface runoff or ponding.	Clean-up/isolation of soil and contained groundwater only, in immediate vicinity of release. Unlikely to be off-site liabilities or action by statutory authorities with respect to groundwater. Low cost implications.

Surface Water (exc coastal waters)

Sensitivity Assessment	Standard Response	Implications/need for further work (subject to nature of source and pathway and no short circuiting by artificial drainage systems)
H1 (Very high)	High quality watercourse (GQA A or B) within close proximity (less than 250m) of site or with potential for rapid transmission of pollutants to that watercourse via a fissured aquifer. Or interconnected unclassified drain or stream.	Potential for major pollution incident with fish kills, risk to river users etc. Major cost implications for remediation measures and with respect to penalties on prosecution. Potential for major adverse publicity.
H2 (High)	Site within catchment and reasonable proximity (less than 500m) of high quality watercourse (GQA A/B) or with potential transmission of pollutants via baseflow from an aquifer with little subsurface attenuation or via an interconnected unclassified drain or stream.	Potential for significant pollution incident that requires remedial measures and likely to involve a prosecution and adverse publicity. Substantial cost implications.
M1 (Moderately high)	Site within catchment and reasonable proximity (less than 500m) of a moderate quality watercourse (GQA C/D) or 500-1000m of a high quality watercourse (GQA A/B). Also where there is potential transmission of pollutants via baseflow with little subsurface attenuation or via an interconnected unclassified drain or stream.	Potential for significant pollution incident that requires remediation measures. Possible prosecution, particularly if contamination is likely to be visible or result in public complaints.
M2 (Moderate)	Site within catchment of and relatively close (less than 1000m) to moderate or poor quality (GQA C to F) watercourse that may be subject to planned improvement by attainment of surface water quality objectives. May be potential for transmission of pollutants via baseflow from a highly permeable formation.	Minor incidents are unlikely to attract third party liabilities, but action by statutory authorities likely if contamination is visible or repeated.
L1 (Low)	Within catchment of and over 250m from generally poor quality watercourse (GQA E or F) that is unlikely to improved by current or foreseeable surface water quality objectives or at distance (over 1000m) from a good quality watercourse with no interconnecting drains or baseflow from fissured strata.	Unlikely to be third party liabilities or action from statutory authorities from surface water viewpoint.
L2 (Very low)	No surface water within general area of the site (at least 250m) or closed drainage within site. Little or no potential for significant transmission via baseflow and no interconnecting drains.	Liabilities restricted to site itself (localised soil contamination or ponding) or associated with groundwater.

Coastal Waters

Sensitivity Assessment	Standard Response	Implications/need for further work (subject to nature of source and pathway and no short circuiting by artificial drainage systems)
H1 (Very high)	Within 100m of a sensitive coastal water, that is, a recognised bathing water, a "more sensitive area" (as defined under the Urban Wastewater Treatment Directive) or a marine SSSI or at a greater distance but with a direct connection via a stream or a highly fissured aquifer to such a coastal water with the potential for rapid flow to that water.	Potential for major environmental health risks and ecological damage. Probability of high remedial costs, prosecution and adverse publicity.
H2 (High)	As above, within 250m or with a relatively rapid route of transmission or within 100m of a "less sensitive area".	
M1 (Moderately high)	Within 500m of a bathing water or a defined sensitive area (see above); with possibility of diffuse flow via groundwater seepages at coastline or with connection via nearby watercourses.	LESS DATA AVAILABLE FOR COASTAL SITES TO GIVE GENERALISED ASSESSMENTS OF POTENTIAL LIABILITIES.
M2 (Moderate)	Within 500m of a coastal water (undefined), with possibility of diffuse flow via groundwater seepages at coastline or with connection via nearby watercourses.	
L1 (Low)	No coastline nearby (within 1km), but with possibility of diffuse groundwater seepages at coastline or connection via nearby watercourses.	Liabilities initially associated with watercourses or groundwaters.
L2 (Very low)	No coastline nearby (within 1km) and/or no direct connection via surface or ground water.	No liabilities likely.

Artificial Drainage System

Sensitivity Assessment	Standard Response	Implications/need for further work (subject to nature of source and pathway and no short circuiting by artificial drainage systems)
H1 (Very high)	Extensive land use/industrial history, successive building development. Steep surface slopes (rapid travel times with little opportunity for dilution/ interception facilities) or close proximity (within 250m) to surface watercourses or high sensitivity groundwater. Former mining areas where subsurface mine drains are present or suspected. Detailed drainage records absent.	Probability of interconnection of artificial and natural drainage systems, with consequent risks to sewers, surface and ground water. Potential unconsented connections and discharges on and off-site with third party pipes/structures, risk of third party action and additional effluent treatment costs. Potential damage to site fabric and structures due to leakages and collapse. Major cost implications for investigation and implementation of remedial measures. Drainage investigation and risk assessment essential.
H2 (High)	As above, but shallower slopes (longer retention times in drains) or more distant (over 250m) to surface watercourses or with detailed records of drainage systems.	As above, but potentially lower investigatory and remedial costs. Drainage investigation and risk assessment essential.
M1 (Moderately high)	More than one phase of site development with limited historic records of drainage systems (sewers, surface water, pipelines). Over 250m from surface watercourse.	As above, but less extensive drainage investigation and reduced investigation and remedial costs.
M2 (Moderate)	More than one phase of site development with detailed historic records of drainage systems (sewers, surface water, pipelines).	As above, costs likely to be dependent on-site processes and degree of maintenance of existing drainage systems.
L1 (Low)	Recent (greenfield) development, with recorded and low intensity drainage systems or older sites with thoroughly investigated and recorded drainage systems, drainage risk assessment and implementation of remedial measures. Within 250m of surface watercourses or on low permeability strata. No mine drains.	Leakages from drains may contaminate soil locally and eventually reach a watercourse. Low risk of third party action.
L2 (Very low)	Recent (greenfield) development, with recorded and low intensity drainage systems, or older sites with thoroughly investigated/recorded drainage systems, drainage risk assessment and implementation of remedial measures. Remote from surface watercourses, all drainage to adopted sewers and with no permeable strata within 10m of the site surface. No mine drains.	Leakages from drains may contaminate soil locally.

Table A – Consequence of Risk

CLASSIFICATION	DEFINITION	EXAMPLES
Severe	Highly elevated concentrations likely to result in "significant harm" to human health as defined by the EPA 1990, Part 2A, if exposure occurs. Equivalent to EA Category 1 pollution incident including persistent and/or extensive effects on water quality; leading to closure of a potable abstraction point; major impact on amenity value or major damage to agriculture or commerce. Short term risk of pollution of sensitive (H1/H2) water resource. Major damage to aquatic or other ecosystems, which is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population. A short term risk to a particular ecosystem, or organism forming part of such ecosystem. Catastrophic damage to crops, buildings or property.	Significant harm to humans is defined in circular 01/2006 as death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Major fish kill in surface water from large spillage of contaminants from site. Highly elevated concentrations of List I and II substances present in groundwater close to small potable abstraction (high sensitivity). Explosion, causing building collapse (can also equate to immediate human health risk if buildings are occupied).
Medium	Elevated concentrations which could result in "significant harm" or "significant possibility of significant harm" to human health as defined by the EPA 1990, Part 2A if exposure occurs. Equivalent to EA Category 2 pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce. Pollution of a highly sensitive (H1/H2) water resource. Significant damage/change to aquatic or other ecosystems, which may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. Significant damage to crops, buildings or property.	Significant harm to humans is defined in circular 01/2006 as death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions. Damage to building rendering it unsafe to occupy e.g. foundation damage resulting in instability. Ingress of contaminants through plastic potable water pipes.
Mild	Exposure to human health unlikely to lead to "significant harm". Equivalent to EA Category 3 pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture or commerce. Pollution of moderately sensitive (M1/M2) water resources. Minor or short lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population. Significant damage to crops, buildings, structures and services ("significant harm" as defined in Circular 1/2006).	Exposure could lead to slight short-term effects (e.g. mild skin rash). Surface spalling of concrete.
Minor	No measurable effect on humans. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects of damage to buildings, structures and services. Pollution of low sensitive (L1/L2) water resource. Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The loss of plants in a landscaping scheme. Discoloration of concrete.

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

Table B – Probability of Risk Occurring

CLASSIFICATION	DEFINITION	EXAMPLES
High likelihood	There is pollutant linkage and an event would appear very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution.	a) Elevated concentrations of toxic contaminants are present in soils in the top 0.5m in a residential garden. b) Ground/groundwater contamination could be present from chemical works, containing a number of USTs, having been in operation on the same site for over 50 years.
Likely	There is pollutant linkage and all the elements are present and in the right place which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term.	a) Elevated concentrations of toxic contaminants are present in soils at depths of 0.5-1.0m in a residential garden, or the top 0.5m in public open space. b) Ground/groundwater contamination could be present from an industrial site containing a UST present between 1970 and 1990. The tank is known to be single skin. There is no evidence of leakage although there are no records of integrity tests.
Low likelihood	There is pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a long period such an event would take place, and is less likely in the shorter term.	a) Elevated concentrations of toxic contaminants are present in soils at depths >1m in a residential garden, or 0.5-1.0m in public open space. b) Ground/groundwater contamination could be present on a light industrial unit constructed in the 1990s containing a UST in operation over the last 10 years – the tank is double skinned but there is no integrity testing or evidence of leakage.
Unlikely	There is pollutant linkage but circumstances are such that it is improbable that an event would occur even in the very long-term.	a) Elevated concentrations of toxic contaminants are present below hardstanding. b) Light industrial unit <10 yrs old containing a doubleskinned UST with annual integrity testing results available.

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

Table C – Calculation of Risk

		CONSEQUENCE			
		Severe	**Medium**	**Mild**	**Minor**
PROBABILITY	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very low Risk	Very low Risk

The above evaluated risk terms are described hereunder in Table D:

Table D – Description of the Evaluated Risks from Table 3

EVALUATED RISK	DESCRIPTION
Very High Risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High Risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the long term.
Moderate Risk	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	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.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.
No Potential Risk	There is no potential risk if no pollution linkage has been established.

The likely action required for each of the above evaluated risks is as follows:

Action in the form of site investigation and risk assessment, mitigation of risk or remediation of contamination is required at sites evaluated as **Very High Risk** or **High Risk**.

Site investigation is required at sites evaluated as **Moderate Risk**.

No action is required at sites evaluated as **No Potential Risk**, **Low Risk** or **Very Low Risk.**

Tier 2: Generic Quantitative Risk Assessment (GQRA)

GQRA requires an intrusive investigation in order to characterise the site assisting in the re-assessment of the source-pathway receptor linkage. The conceptual model should be refined accordingly.

If GQRA reveals that unacceptable risks are not present then no further action is required. If GQRA identifies a possibility of risk, a decision must be made whether further work is required or necessary for the purposes of risk assessment. If further risk assessment is deemed not suitable / not required an Options Appraisal should be undertaken. If further risk assessment is required, the scope / nature of further risk assessment must be decided – it is possible that a Tier 3 DQRA will be undertaken in this scenario.

Tier 3: Detailed Quantitative Risk Assessment (DQRA)

DQRA is used when pollutant linkages require further assessment. DQRA is often undertaken for pollutant linkages where GAC are unavailable or inappropriate for or more conservative than the actual circumstances of the site. Site specific data is used to create Site Specific Assessment Criteria (SSAC) and enable a more accurate assessment of the risks. Further investigation may or may not be required to formulate SSAC depending on the site specific conditions and information already obtained.

If DQRA reveals that unacceptable risks are not present then no further action is required. If DQRA identifies a possibility of risk, a decision must be made whether further work is required or necessary for the purposes of risk assessment. If further risk assessment is deemed not suitable / not required an Options Appraisal should be undertaken. If further risk assessment is required, the scope nature of further risk assessment must be decided.

NOTE: A Tier 1 Preliminary Risk Assessment is undertaken as part of a Desk Study Report and a Preliminary Conceptual Model is developed for all pollutant linkages including risks ground gas and controlled waters. The methodologies for assessing the risks to human health, risks to controlled waters and risk posed by ground gas using quantitative techniques vary considerably, therefore GQRA and DQRA for human health, controlled waters and ground gas must be undertaken separately. The risk assessment methodologies where quantitative assessment is used for risks to human health, risks to controlled waters and risks posed by ground gas, if relevant, are described hereunder.

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY – SOIL AND WATER

Background

In January 2009, the EA published the revised 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 together with associated "TOX" and "SGV" documents are continually being published and will be used in any assessment.

Guidance on statistical assessment is given in CL:AIRE :2008 "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 determine whether the site is suitable for new development in according with planning guidance. This is discussed further in CL:AIRE :2008 "Guidance on Comparing Data With a Critical Concentration".

COLLATION OF SOIL TOXICOLOGICAL DATA

The toxicological data collated by ***Demeter Environmental Ltd*** is presented as a separate document, available to regulatory bodies on request. The data gathered is generally in accordance with the hierarchy given in the EA Science Report SC050021/SR21 "Human health toxicological assessment of contaminants in soil". The hierarchy may be circumvented where more up to date authoritative data from a toxicological study has been published from sources lower down the hierarchy.

DERIVATION OF SOIL ASSESSMENT CRITERIA

GAC's derived by ***Demeter Environmental Ltd*** are based on a Soil Organic Matter (SOM) content of 1%. Whilst this approach differed from the Environment Agency (who have published SGV's based on a 6% SOM) it provides a more conservative GQRA. Where SSAC's are required, site specific SOM will be used in the DQRA. Where available, other parameters such as building size, receptor and soil characteristics will be used in the DQRA.

Assessment criteria are available from a number of sources, namely (and in order of use):

1. Land Quality Management Suitable for Use Levels (S4UL's) (Copyright Land Quality Management Limited reproduced with permission; Publication number S4UL3093. All rights reserved);
2. C4SL for lead;
3. EIC/AGS/CL:AIRE Generic Assessment Criteria;
4. In-house derived GAC's / S4UL's.

STATISTICAL ASSESSMENT OF SOIL CONTAMINATION DATA

In any site investigation only a small fraction of the soil on the site is analysed. Therefore the mean derived from the contamination data for a contaminant may not be the same as the true mean for the contaminant distribution on the site. To improve the reliability of any assessment a statistical analyses is if the dataset is undertaken.

The statistical assessment is undertaken using ProUCL, which is published by the USEPA, which provides a statistical assessment that exceeds the guidance given in the CL:AIRE document "Guidance on Comparing Soil Contamination Data with a Critical Concentration".

Where the number of results in a dataset is less than four, a statistical assessment cannot be undertaken, and the assessment is performed by comparison of the maximum value(s) with the assessment criteria. Dependant on the distribution of the data, a statistical analysis may not be feasible and in those cases the results will be assessed directly to their respective assessment criteria.

If the screening levels are exceeded then more sophisticated quantitative risk assessment can be undertaken or remedial action may be taken to break the pollutant 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.

ASSESSMENT OF RISK TO HUMAN HEALTH

ASSESSMENT VALUES

Assessment criteria are available from a number of sources, namely:

1. Land Quality Management Suitable for Use Levels (S4UL's) (Copyright Land Quality Management Limited reproduced with permission; Publication number S4UL3093. All rights reserved);
2. C4SL for lead (the C4SL is used in lieu of the in house derived GAC as it provides a more conservative assessment);
3. EIC/AGS/CL:AIRE Generic Assessment Criteria;
4. In-house derived GAC's / S4UL's

TIER 2 GENERIC ASSESSMENT CRITERIA FOR SOILS

Generic Assessment Criteria (GAC's) have been derived by ***Demeter Environmental Ltd*** to aid in the assessment of the risk to human health. These are derived using CLEA v1.06. Details of the derivation of the GAC's are provided within the Report. GAC's are based on generic assumptions on the land use, building and soil parameters.

SITE SPECIFIC ASSESSMENT CRITERIA FOR SOILS

Where there are exceedances of the Tier 2 GAC, Site Specific Assessment Criteria (SSAC) are derived, using site specific data for the Soil Organic Matter (SOM), building parameters, land use etc. An SSAC, like SGV's, S4UL's and GAC's is a threshold below which the risk is minimal.

Whilst CLEA v1.06 is normally used to derive SSAC's, other risk assessment packages may be used if they are more suitable for the subject site.

ASSESSMENT OF RISK TO HUMAN HEALTH FROM SOIL WATER

Where exposure to contamination in soil water is significant this will be assessed using BP RISC (amended to be as close to UK compliant as possible).

CONTROLLED WATER RISK ASSESSMENT METHODOLOGY

Background

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. From the 1st October 2004, the definition of groundwater in relation to Part IIA was amended, by the Second Water Act Commencement Order SI 2004 No 2528. 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).

INTRODUCTION

Demeter Environmental Ltd utilises the methodology for the assessment of groundwater as discussed in the Environment Agency publication 'Remedial Targets Methodology and Policy and Protection of Groundwater.

The procedure for determining site-specific remedial targets is summarised below:

1) Determine a target concentration at the receptor or compliance point in relation to its use.

2) Undertake the tier assessment to determine whether the contaminant source would result in the target concentration being exceeded at the receptor or compliance point. At each tier, a remedial target is determined.

3) If the contaminant concentrations on-site exceed the remedial target, then the decision whether it is appropriate to upgrade the tier analysis is based on:

- timescale – the decision to proceed to the next tier analysis should only be made if any risk involved in delaying the decision to implement the remedial action is acceptable;
- what additional information is required and can be obtained;
- cost-benefit analysis, i.e. the cost of tier upgrade in relation to the potential reduction in the cost of the remedial solution.

Four assessment tiers are proposed for the assessment of contaminated soil to protect water resources:

Level 1 considers whether contaminant concentrations in "pore water" in contaminated soil are sufficient to impact on the receptor, ignoring dilution, dispersion and attenuation along the pathway. The "pore water" concentration is determined from:

i) measured "pore water" concentrations or perched water quality;
ii) soil leaching tests;
iii) theoretical calculations based on soil/water partitioning equations.

Level 2 considers dilution by the receiving groundwater or surface water body and whether this is sufficient to reduce contaminant concentrations to acceptable levels. The remedial target is defined as the target concentration multiplied by a dilution factor (DF).

Levels 3 and 4 consider whether natural attenuation (including dispersion, retardation and degradation) of the contaminant as it moves through the unsaturated and saturated zones to the receptor are sufficient to reduce contaminant concentrations to acceptable levels. The remedial target is defined as target concentration multiplied by a dilution factor (DF) and attenuation factor (AF). In Level 3 simple analytical models are used to calculate the significance of attenuation, whereas in Level 4 more sophisticated numerical models are used.

For each level, the "pore water" concentration determined for the soil zone is compared to the remedial target to determine the need for remedial action.

The assessment in relation to contaminated groundwater commences at Level 2 as the contaminants have already moved through the soil zone, so that the only processes of significance are attenuation, dispersion and further dilution of this groundwater as it moves from the source towards the receptor. Thus the assessment levels for contaminated groundwater are:

Level 2 – the observed contaminant concentration in groundwater below the site is compared directly to the target concentration.

Levels 3 and 4 – the observed groundwater concentration below the site is compared directly to the target concentration multiplied by an attenuation factor (AF); as with the soil levelled assessment, Levels 3 and 4 are distinguished by the sophistication of the modelling and prediction processes.

BACKGROUND INFORMATION, CURRENT GUIDANCE AND RISK ASSESSMENT METHODOLOGY FOR RISKS POSED BY GROUND GAS

Background

Origin of Ground and Landfill Gases

When carrying out a ground gas risk assessment, the origin or source of the gases is important as potential risks will vary depending on the source. This Appendix relates to the risk of the two main ground gases of concern; methane and carbon dioxide, and does not apply to other ground gases (e.g. radon or vapours from hydrocarbon spills). Methane and carbon dioxide are major constituents of ground gas but can also occur from a variety of anthropogenic and natural sources, as summarised in Table E below. The generation potential of each source is given below.

Table E- Sources and Origins of Ground Gases

Source	Origin		Typical Range of Concentrations			Generation Potential
			Methane	Carbon Dioxide	Others	
Anthropogenic						
Landfill sites (include shallow and old landfill)	Microbial decay of organic materials derived from the disposal of putrescible materials	Landfill gas is a product of the biodegradation of organic materials contained in wastes deposited in landfill sites. Age and composition of landfill affect the gas regime. The gas regime will also be influenced by physical parameters such as volume/depth of waste and the groundwater regime, as well as environmental factors such as temperature, moisture content and pH value. These factors are considered in some detail in earlier CIRIA guidance (Barry et al, 2001). The Environment Agency Guidance on the management of landfill gas provides useful information on the mechanisms by which landfill gas is generated, its composition and physical and chemical characteristics and behaviour (Environment Agency, 2004a). Leachate from landfill sites may also contain dissolved gases or may degrade during migration to produce methane with carbon dioxide and associated gases.	20-65%	15-40%	Several hundred trace organic gases (maybe odorous or toxic) (generally makes up <1% of total volume, eg H_2S	Very high if the landfill has recently closed (post 1960) Moderate (pre 1960 landfills) Very low (inert landfills)
Made ground	Microbial decay of organic materials contained in reworked natural ground containing demolition and other wastes	Made ground will often contain degradable material such as wood, rags, paper and vegetation. However, the proportion of such carbon-rich materials is typically low, with major components often comprising re-worked clays, silts, sands and gravels together with anthropogenic inclusions such as ash, clinker, brick, concrete etc. Many brownfield sites contain made ground and on these sites the methane concentrations are usually not highly elevated, although there are exceptions, while concentrations of carbon dioxide can typically range to higher values. The rate of gas generation also tends to be low, resulting in small but sustained volumes of gas. There often tends to be a lack of driving force within made ground (see Section 2.6.1). The low rate of gas generation, the limited driving force and the fact that the gas is denser than air result in little upward migration of carbon dioxide.	0-20%	0-10%		Very low (inert made ground) Low (made ground with high levels of organic/ putrescible matter)
Foundry sands	Microbial decay of waste materials from the foundry process (phenolic binders, dextrin, coal dust, wood rags, paper)	In foundry sands, organic materials resulting from the foundry process such as phenolic binders, detrin and coal dust, and other foundry wastes such as wood, lignin and paper can provide a substrate for methanogenic bacteria (Hooker et al, 1993)	Up to 50%	15-40%	Trace organic gases (generally <1% of total volume) (maybe odorous and/or toxic)	Very low to low depending on presence of organic/ putrescible matter

Table E (continued)- Sources and Origins of Ground Gases

Source	Origin		Typical Range of Concentrations			Generation Potential
			Methane	Carbon Dioxide	Others	
Anthropogenic						
Sewage sludge, dung, cess pits/heaps	Microbial decay of organic materials	Methane and carbon dioxide are the main components associated with the anaerobic decomposition of organic components of sewage (Hooker et al, 1993). Hydrogen sulphide is also often present resulting from the degradation of organic matter and sulphur containing compounds (including mercaptans) in the sewage. Nitrogen oxide and ammonia gases are also associated with sewage. These gases can be a problem in sewer systems with confined spaces such as pipework, manholes and service chambers which can lead to potentially explosive, asphyxiating or chemically harmful atmospheres. Additionally the formation of sulphuric acid from the oxidation of hydrogen sulphide can corrode pipes, resulting in migration into the surrounding soils.	60-75%	18-40%	Trace organic gases (generally <1% of total volume) (maybe odorous and/or toxic)	Moderate
Burial Grounds (including cemeteries)	Microbial decay of organic materials contained within human/animal remains.	The generation of gases from the decomposition of corpses is well documented (Polson et al, 1975). The gases generated are predominantly carbon dioxide and methane with trace amounts of odorous sulphur-containing gases. Diphosphane may be generated by anaerobic decomposition of phosphorus in skeletal material (generally in waterlogged areas). Other gaseous emissions may include formaldehyde, associated with the preparation of cadavers and present in medium density fibreboard (MDF), widely used to make coffins.	20-65%	15-40%		Moderate
Industrial/chemical/petroleum sites/manufacturing	Organic vapours derived from leaks or spills from storage, processing and disposal areas		3-100%	2-8%	Trace organic gases (generally <1% of total volume) (maybe odorous and/or toxic), cyanide	Low
Natural gas (supply pipes)	Leakage from bulk pipeline transportation of natural gas	Mains gas is derived from the same geological source as methane in coal mines. Leaks into surrounding soils can occur from damaged or poorly maintained underground pipes. In the UK, a combination of mercaphens and sulphide are added as odourants which can often be detected. Ethane additives will also indicate the presence of distributed main gases.	90-95%	0-9.5%	1 – 27% C2-C4 alkanes, 4.7% CO	Low

Table E (continued)- Sources and Origins of Ground Gases

Natural						
Soils	Physical, chemical and biological transformations of rock during weathering		<2ppm	350ppm		Very low (none if no organic material is present)
Coal measures strata	Burial of vegetation under high temperatures and pressures, liberating gases as a by-product as a result of mining activities	Methane is associated with coal bearing carboniferous strata, produced by the anaerobic decomposition of ancient vegetation trapped within the rock. Associated gases include higher alkanes (for example ethane), hydrogen and helium. Former shafts and/or fractured rock can provide a migration pathway to the surface and rising groundwater or flooding of mine workings can release trapped methane and carbon dioxide.	<1-90%	0-6%	4–13% C_2-C_4 alkanes, 0 – 10% CO production of H_2S possible but rarely occurs in hazardous concentrations	High (active mine working) Moderate (abandoned mine working) Very low (flooded mine workings)
Peat/bog areas	Gas formed by the microbial decay of accumulated plant debris under anaerobic conditions	Methane from these sources is produced by the microbial decay of organic material under anaerobic conditions, usually waterlogged vegetation. Carbon dioxide is usually produced by acid reaction on carbonate fraction in any alluvial soil, and also generated by methane oxidation. Trace gases include hydrogen sulphide and light hydrocarbons. Methane can migrate large distances through soils. The source of the methane which caused the explosion at Abbeystead in 1985 was naturally occurring oil shales at more than 1 km depth.	10-90%	0-5%		Moderate
Alluvium (organic rich sediments)			0-5%	0-10%		Low (may be very low depending on levels of organic matter)
Radon emitting rocks	Decay of naturally occurring uranium within soils and rocks	Radon is a radioactive gas that occurs naturally and has no taste, smell or colour. It is formed from the decay of uranium, which is found in small quantities in all soil and rocks, in particular granite. Radionuclides (the decay products of radon) can damage lung tissues and ultimately lead to lung cancer. An action level of 200 Bq/m³ was set by the former National Radiological Protection Board	Variable	Variable	0-1000 Bq/m³ radon gas. Higher concentrations of gas up to 4,000,000 Bq/m³ have been recorded in the southwest	N/A
Carbonate rich strata	Dissolution of calcium carbonate by acidic water	Acidic waters such as rainwater can react with calcium carbonate (e.g. chalk and limestones etc) to form carbon dioxide. Elevated concentrations of carbon dioxide (>five per cent) have been detected in confined spaces particularly those associated with groundwater abstraction infrastructure such as pump houses, located in chalk areas.	Variable	1-9%		Very low to low depending on water content

This does not provide guidance for the assessment of risk when other gases are present due to 'Other Sources' from the above table (particularly volatile organic compounds or for the risk from radon or hydrogen sulphide).

To determine the origin of the gas a range of factors must be considered together, including;

1. Proximity of likely sources
2. Ground conditions (geology, hydrogeology, anthropogenic pathways etc)
3. Properties of gases present including:
    - Chemical composition
    - Physical properties
    - Ratios of components e.g. methane: carbon dioxide
4. Timeframe of activities such as infilling periods, capping works, installation of gas control systems etc

Identification of the originating source may be problematic given that there may be more than one source present and trace gas analysis may be required. Identification of the sources of the gases encountered during monitoring is usually carried out through a process of eliminating the most unlikely potential sources (given the site setting) and selecting those which are most likely.

Hazards Associated with Presence of Methane

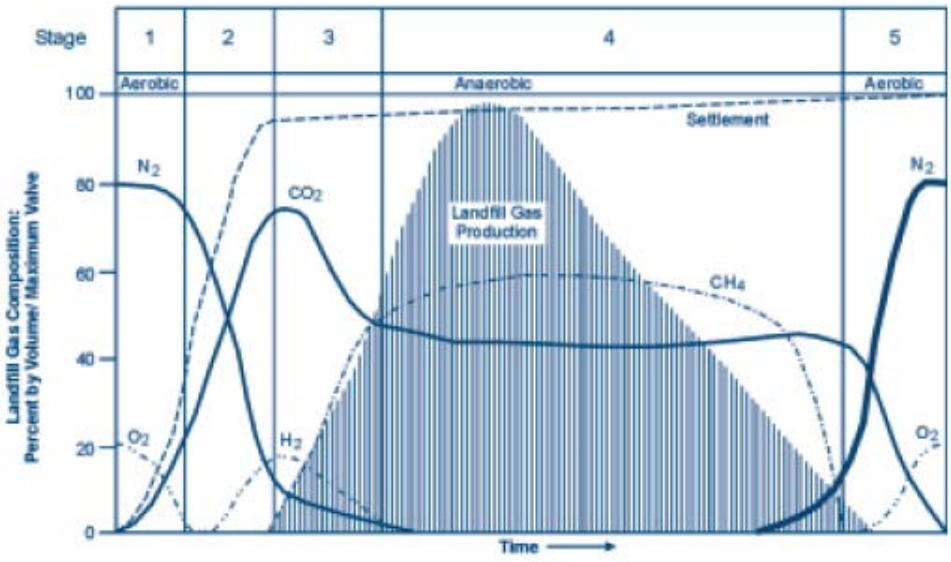
Methane gas is combustible and potentially explosive. When the concentration of methane in air is between the limits of 5.0%v/v and 15.0%v/v an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5.0%v/v, which is equivalent to 100% LEL. The 15.0%v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations. Further, the LEL and UEL will vary (up and down) depending upon the proportion of other gases (including oxygen). However, the fact that methane is a colourless, odourless gas means that there is no simple indicator of the presence of the gas until such a time as explosive limits are reached and an incident occurs. Methane is lighter than air and has a low toxicity. However, at high concentrations it can result in asphyxiation due to oxygen displacement.

Hazards Associated with Presence of Carbon Dioxide

Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both toxic and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions. The UK Health & Safety Executive (HSE) has published information relating to concentrations of carbon dioxide that humans may be exposed to, which uses concentrations contained in the Control of Substances Hazardous to Health Regulations 2002 (as amended). These are the Long Term Occupational Exposure Limit (LTOEL, 8 hour period) and the Short Term Occupational Exposure Limit (STOEL, 15 minute period), which are 0.5% and 1.5% carbon dioxide, respectively.

Parameters Influencing the Rate of Ground Gas Production

The figure below is taken from EA guidance document LFTGN 03 illustrates typical ground gas generation curves from biodegradable materials:



The production of methane and carbon dioxide at a landfill site may be expected to be considerable and ongoing. Concentrations of methane will eventually decrease, followed by concentrations of carbon dioxide, but the duration and rate of gas production can vary markedly between sites. Five distinct phases of gas production occur during the process which are, in order of event as marked above, as follows:

1. An aerobic phase involving oxygen depletion and temperature increase through aerobic respiration;
2. The establishment of anaerobic conditions and the evolution of carbon dioxide and hydrogen through acidogenic activity;
3. Commencement of methanogenic activity; the establishment of populations of methanogenic bacteria;
4. A phase of stable methanogenic activity, which may go on for many tens of years;
5. A phase of decreasing methanogenic activity, representing depletion of the organic material and a return to aerobic conditions.

The time scale for the return to the normal ground gas concentrations will be highly variable, depending upon the types and quantities of materials present. In addition, the optimum parameters influencing the rate of decomposition and ground gas production within the ground at a site are as follows:

- High water content with adequate rainfall and water infiltration to provide moisture content between approximately 20 to 26%;
- Conditions that either are or are very close to anaerobic;
- High proportion of biodegradable materials;
- A pH between 6.5 and 8.5, ideally verging slightly on the acidic between pH 6 to 7;
- Temperature between 25°C and 55°C;
- The ratio of the biochemical and chemical oxygen demands (BOD:COD);
- High permeability;
- Small particle size, as finer subsurface materials possess a greater surface area to provide a growing 'face' for the micro-organisms but high fines levels reduces permeability and reduces decomposition rate.

For this reason, it is vital that sources of methane and carbon dioxide are identified prior to the commencement of any work on a construction site, and that the ground gas regime is characterised at the worst temporal conditions a site may experience. From this, a risk assessment is carried out to identify the risk at the site from ground gases so that suitable protection measures can be designed and incorporated into a development to prevent a dangerous build-up of gas occurring.

Factors Influencing the Migration and Behaviour of Ground Gases

There are many factors that influence the migration of ground gases which can affect the risk from a gassing source:

- driving force – pressure differential along a pathway, diffusion and dissolved in solution;
- meteorological conditions – short term and seasonal conditions including atmospheric pressure changes (e.g. rapidly falling pressure causes gas to expand increasing emission rates), rainfall, frozen ground and thawing, temperature;
- geological and groundwater conditions – these can have the over riding influence on the direction/pathways and quantity of migrating gas;
- anthropogenic influences – man-made pathways include mine shafts, service runs/drains, foundation piles, underground voids/pits/basements, foundation/building design/construction

Ground Gas Risk Assessment Methodology

Assessment of risk posed by ground gas is undertaken using the methodology as outlined previously, and summarised hereunder:

- Tier 1 Preliminary Risk Assessment
- Tier 2 Generic Quantitative Risk Assessment
- Tier 3 Detailed Quantitative Risk Assessment

The methodology used in each of the above assessments with concern to ground gas is discussed hereunder.

<u>Tier 1 Preliminary Risk Assessment</u>

All potential sources of methane and carbon dioxide are identified in the Preliminary Conceptual Model and the generation potential determined. The background information discussed earlier is referred to in order to determine the potential for a source to generate ground gas.

CIRIA C665 provides idealised monitoring frequency / period dependent upon generation potential of gas source and sensitivity of the proposed land use as below:

Idealised Frequency and Period of Monitoring (after Table 5.5a and 5.5b, CIRIA C665)

		Generation Potential of Source				
		Very Low	**Low**	**Moderate**	**High**	**Very High**
Sensitivity of Development	**Low** (Commercial)	4/1	6/2	6/3	12/6	12/12
	Moderate (Flats)	6/2	6/3	9/6	12/12	24/24
	High (Residential with Gardens)	6/3	9/6	12/6	24/12	24/24

Notes

1. First number is the number of readings and the second is the minimum period in months (e.g. 6/2 – six sets of readings over two months).

2. At least two sets of readings must be at low (preferably under 1,000 mb) and falling pressure.

The monitoring programme is decided using the above table prior to the intrusive site investigation. However, if the intrusive investigation reveals that a potential source is better or worse than anticipated the monitoring programme should be modified accordingly. For example, if the made ground contains no evidence of organic material and comprises entirely granular brick fill, the potential for that made ground to generate ground gas is reduced considerably.

Tier 2 Generic Quantitative Risk Assessment

Generic Quantitative Risk Assessment is undertaken upon completion of the required gas monitoring period.

All three current guidance documents propose that both ground gas concentrations and flow rates are used to calculate the limiting gas well gas volume flow rates for methane and carbon dioxide, based on the ground gas conditions monitored for during the worse-case temporal conditions. This limiting gas well volume flow rate is termed the Gas Screening Value (GSV, note that this was termed borehole gas volume flow), and is calculated as follows:

$$\textbf{GSV}\ (\text{l/hr}) = \frac{[\text{gas well gas concentration (\%v/v)}] \times [\text{gas well flow rate (l/hr)}]}{100}$$

GSV's are compared to typical max concentrations and limiting gas screening values derived for either Situation A - All development except low rise housing with gardens, or Situation B low rise housing with gardens (NHBC Traffic Light System). Table 8.5 from CIRIA C665 is used for comparison of gas screening values for "Situation A Developments" and is presented hereunder:

Characteristic Situation (CIRIA R149)	Comparable Partners in Technology gas Regime (see Box 8.2)	Risk Classification	Gas Screening Value (CH_4 or CO_2) (l/hr)[1]	Additional Factors	Typical Source of Generation
1	A	Very low risk	<0.07	Typically methane ≤ 1% and/or carbon dioxide ≤ 5%. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" made ground
2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. "Typical" made ground
3	C	Moderate risk	<3.5		Old landfill, inert waste, mine working flooded
4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mine working susceptible to flooding, completed landfill (WMP 26B criteria)
5	E	High risk	<70		Mine working unflooded inactive with shallow workings near surface
6	F	Very high risk	>70		Recent landfill site

Table 8.5 from CIRIA C665 Modified Wilson and Card Classification

Table 8.7 is used for comparison of gas screening values for "Situation B Developments" and is presented hereunder:

Traffic light	Methane [1]		Carbon dioxide [2]	
	Typical max concentration[3] (% by volume)	Gas screening value [2,4] (litres /hour)	Typical max concentration[3] (% by volume)	Gas screening value [2,4] (litres /hour)
Green	1	0.13	5	0.78
Amber 1	5	0.63	10	1.60
Amber 2	20	1.60	30	3.10
Red				

Notes:
1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

CIRIA C665 Table 8.7 NHBC Traffic light system for 150 mm void

Dependant on the outcome of the assessment of risk posed by ground gas it is determined whether gas protection measures are required for the proposed development, and or whether a detailed quantitative risk assessment is required for the site.

Selection & Design of Protective Measures

Table 8.6 and Box 8.4 of CIRIA C665 contain information on the detailed design of protection measures and were initially intended for the purposes of determining then level of protection measures a development requires. These tables and related text include some useful information on the design of gas protection measures, however BS8485:2015 which supersedes the guidance included within CIRIA C665, is used for selection of gas protection measures. BS8485:2015 uses a scoring system dependant on the Characteristic Situation / NHBC Traffic Light and proposed end use of the site. The scoring system is summarised in BS8485:2015 Table 4 as presented hereunder:

Characteristic gas situation, **CS**	**NHBC traffic light**	**Required gas protection**			
		Type A Building (private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises)	**Type B Building** (private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels)	**Type C Building** (commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).	**Type D Building** (industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses.
1	*Green*	0	0	0	0
2	*Amber 1*	3.5	3.5	2.5	1.5
3	*Amber 2*	4.5	4.0	3.0	2.5
4	*Red*	6.5 (a)	5.5 (a)	4.5	3.5
5		(b)	6.5 (a)	5.5	4.5
6		(b)	(b)	7.5	6.5
NOTE *Traffic light indications are taken from NHBC Report no.:10627-RO1 (04) and are mainly applicable to low-rise residential housing[1]. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.*					
a) Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations. b) The gas hazard is too high for this empirical method to be used to define the gas protection measures					

The NHBC guidance and CIRIA C665 guidance refers to low rise housing (which is up to three storeys without lifts) that is constructed with a 150mm ventilated sub-floor void.

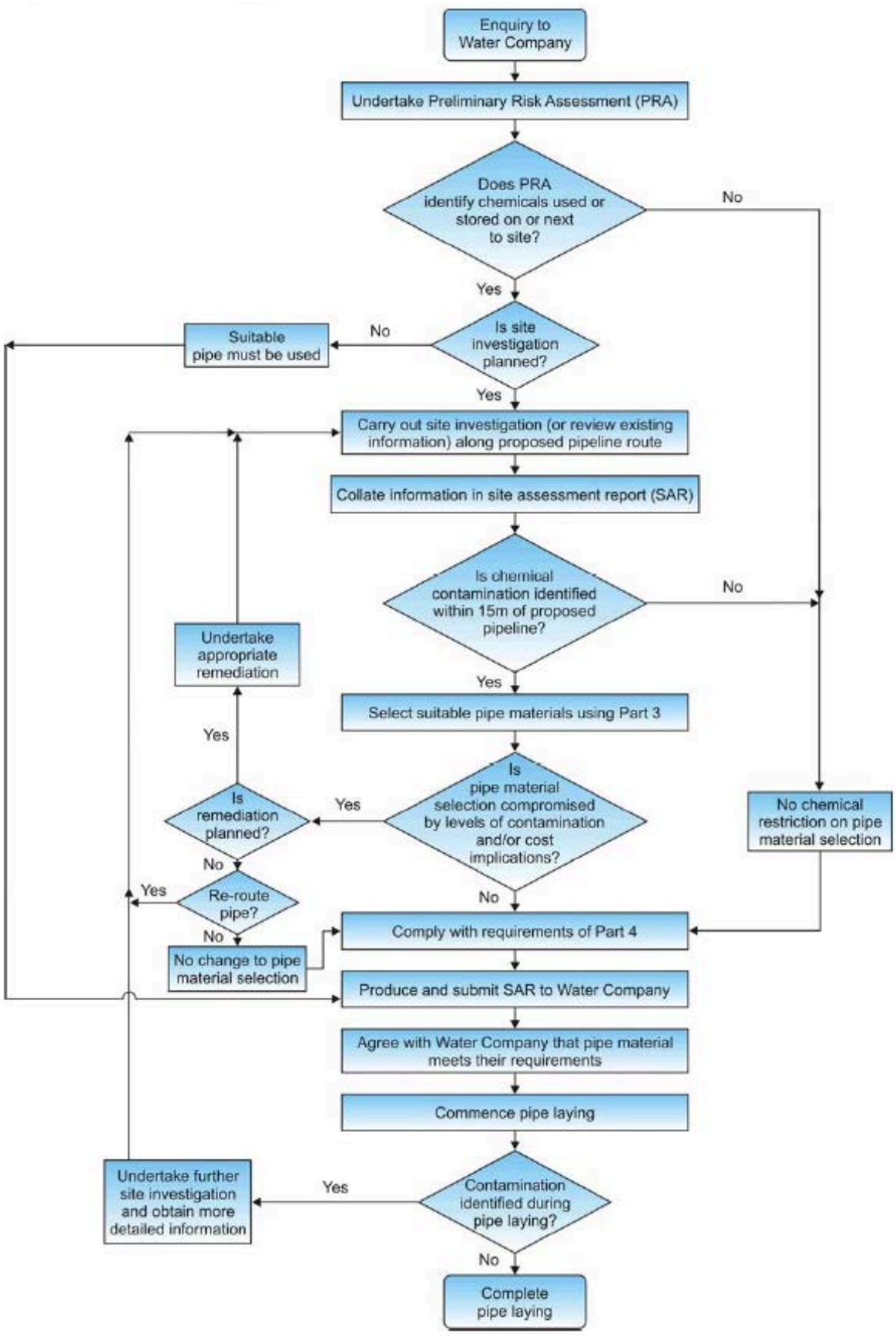
BS8485:2015 Table 2 Required gas protection by characteristic gas situation and type of building

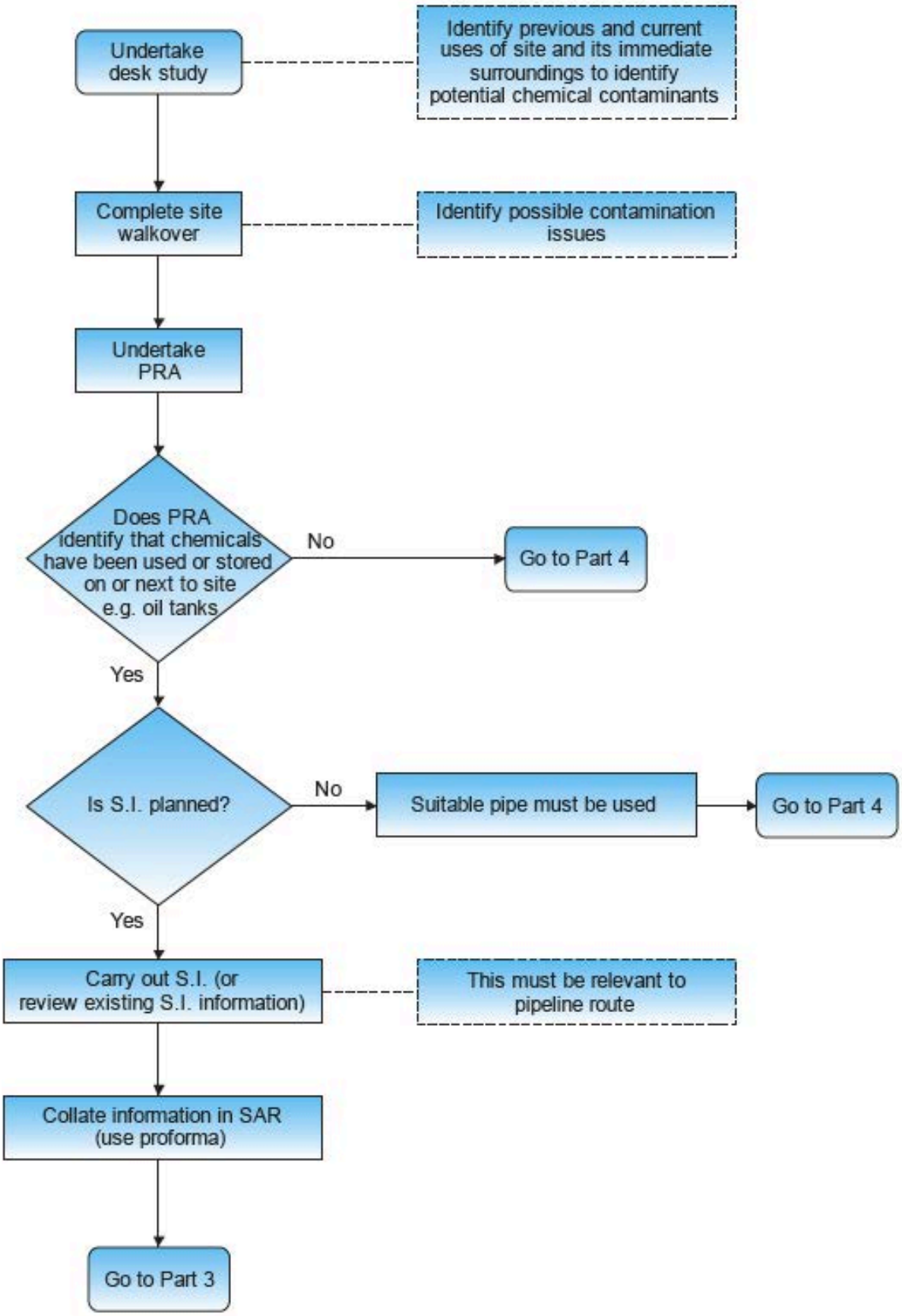
Once a score is assigned, a combination of protection systems / elements is chosen from BS8485:2015 Table 3 shown below:

PROTECTION ELEMENT/SYSTEM	SCORE	COMMENTS
Gas Protection Scores for Ventilation Protection Measures		
Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	0.5	*Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems.* *If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is zero.*
Passive sub floor dispersal layer: Very good performance Media used to provide the dispersal layer are: • Clear void, Polystyrene void former blanket, Geocomposite void former blanket, No-fines gravel layer with gas drains, No-fines gravel layer Good performance	2.5 1.5	*The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in BS8485:2015. Passive ventilation should be designed to meet at least "good performance".*
Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	*This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place.* *There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance", as described in BS8485:2015.*
Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	*This system relies on continued operation of the pumps, therefore alarm and response systems should be in place.* *The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".*
Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4.0	*Assumes that the car park is vented to deal with car exhaust fumes, designed to Buildings Regulations 2000, Approved Document F*
Gas Protection Scores for the Structural Barrier		
Floor and Substructure Design Precast suspended segmental subfloor (i.e. Block and beam floor slab) Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement) Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing (c) Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing (c)	 0 (a) 0.5 (a) 1.0 or 1.5 (a), (b) 2.0 2.5	*a) The scores are conditional on breaches of floor slabs, etc. being effectively sealed;* *b) to achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in;* *c) the score is conditional on the waterproofing not being based on the se of a geosynthetic clay liner waterproofing product*
Membranes		
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • verified in accordance with CIRIA C735	2	*The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. For example, a minimum 0.4 mm thickness (equivalent to 370 g/m2 for polyethelene) reinforced membrane (virgin polymer) meets the performance criteria in BS8485:2015 If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.*

WATER MAINS RISK ASSESSMENT

Risks to water supply pipes are assessed using the document 'Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites' published by the UK Water Industry Research (UKWIR). The methodology for the selection of water pipes in brownfield sites is below:




Undertake desk study
Identify previous and current uses of site and its immediate surroundings to identify potential chemical contaminants
Complete site walkover
Identify possible contamination issues
Undertake PRA
Does PRA identify that chemicals have been used or stored on or next to site e.g. oil tanks
No
Go to Part 4
Yes
Is S.I. planned?
No
Suitable pipe must be used
Go to Part 4
Yes
Carry out S.I. (or review existing S.I. information)
This must be relevant to pipeline route
Collate information in SAR (use proforma)
Go to Part 3

For sites where the preliminarily conceptual site model (PCSM) does not identify the potential for chemical storage either on or next to the site, there are no chemical restrictions on the selection of pipe selection material.

The guidance recommends that if known, samples should be taken along the route of the water mains. At the time of any intrusive investigation the route of the water mains is generally unknown, hence the guidance recommends that samples are taken across the site.

Table 1: Pipe Selection Table

	Pipe Material					
	All thresholds are in mg/kg					
Contaminant	**PE**	**PVC**	**Barrier Pipe (PE-AL-PE)**	**Wrapped Steel**	**Wrapped Ductile Iron**	**Copper**
Extended VOC suite by purge and trap or head space and GC-MS with TIC	0.5	0.125	Pass	Pass	Pass	Pass
Total BTEX and MTBE	0.1	0.03	Pass	Pass	Pass	Pass
SVOC's TIC by purge and trap or head space and GC-MS with TIC (aliphatic and aromatic EC5-EC10)	2.0	1.4	Pass	Pass	Pass	Pass
Phenols	2	0.4	Pass	Pass	Pass	Pass
Cresols and chlorinated phenols	2	0.04	Pass	Pass	Pass	Pass
Mineral oil C11-C20 (aromatic/aliphatic EC10-EC16, aromatic EC16-EC21 and aliphatic EC16-35)	10	Pass	Pass	Pass	Pass	Pass
Mineral oil C21-C40 (aliphatic EC16-EC35 and aromatic EC21-EC35)	500	Pass	Pass	Pass	Pass	Pass
pH	Pass	Pass	Pass	Corrosive if pH<7 and conductivity >400uS/cm	Corrosive if pH<5, Eh not neutral and conductivity >400uS/cm	Corrosive if 5<pH>8 and Eh positive
Conductivity						
Redox						
SPECIFIC SUITE IDENTIFIED AS RELEVANT FOLLOWING SITE INVESTIGATION						
Ethers	0.5	1.0	Pass	Pass	Pass	Pass
Nitrobenzene	0.5	0.4	Pass	Pass	Pass	Pass
Ketones	0.5	0.02	Pass	Pass	Pass	Pass
Aldehydes	0.5	0.02	Pass	Pass	Pass	Pass
Amines	Fail	Pass	Pass	Pass	Pass	Pass

It can be seen that barrier pipe is suitable on all sites. Where metallic (steel, ductile iron or copper) pipes are to be used, information on the pH, conductivity and redox of the soils will be required to determine suitability. Where PE or PVC pipes are to be laid, information on the presence of organic contaminants identified in the PSCM will be required.

Stage 1 - Assessment Methodology Before Water Mains Alignment is Known

At the time of a Phase II site investigation the alignment of the water mains is generally unknown, and as part of the investigation the entirety of the site will be investigated. The contaminants subject to analysis will be guided by the preliminarily conceptual model, and only contaminants identified in the preliminary conceptual model will be subject to assessment, which will provide a preliminarily specification of water mains.

The site investigation data will be assessed against Table 1 above and a preliminarily assessment of the suitability of water pipe material will be made.

Stage 2 – Assessment Methodology Once Alignment of the Water Mains is Known

Once the alignment of the water mains is known, if cost effective, additional analysis can be undertaken along the alignment to determine if metallic, PE or PVC pipes would be suitable.

RISK TO CONCRETE IN THE GROUND

The risk to buried concrete is assessed in accordance with the BRE Special Digest 1:2005 – 'Concrete in Aggressive Ground'. Recommendations for the composition of concrete and supplementary protective measures (if required) are given on the basis of the assessment.

CURRENT GUIDANCE ON REMEDIATION

When risk assessment of the site has been completed and it 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.

APPENDIX D: FIELDWORK AND SAMPLING METHODOLOGIES

FIELDWORK METHODOLOGIES

1.0 LIGHT CABLE PERCUSSION BORING

1.1 Description of Plant

Cable percussive drilling is the oldest and simplest form of drilling where advancement of the borehole is by hammering (percussion) a tool into the formation by cutting a hole or by bailing out the material. It is the most common form of drilling in the UK.

The type of rig is usually an "A" frame type which arrives on site pulled by a four-wheel drive vehicle. Some cable percussion rigs are fitted to lorry bases and these may offer rotary drilling as well. This system of drilling is very common for geotechnical investigations but is widely used on environmental projects as well. This technique is used mainly for boring into and sampling superficial deposits rather than bedrock. The boring equipment is simple in design and comprises a cable passing from a winch, over a pulley at the top of the rig's mast to the boring tools. The tools are lifted and dropped successively and, as they advance and the borehole is deepened, more cable is fed from the winch drum.

The boring tools are robust steel tubes with a solid weight fitted above them, around 1500 mm long and of diameters ranging from 140 mm to 300 mm. They are designed to sample the ground in that, as the open end hits the formation on the down stroke; material is forced inside and retrieved when the tool is withdrawn at the surface. Water is sometimes added to the borehole to assist in this. Different boring tools are available to suit different types of ground conditions. A shell (a round cylinder with a flap valve) is used in non-cohesive materials while a claycutter (with windows in its sides) is used in cohesive materials. When the ground contains layers of cobbles or boulders that inhibit the boring tools, a chisel can be used instead to break through and then boring resumes below.

As this technique is used mainly in soft ground conditions, the borehole may need to be lined with "casing" that is advanced at the same rate as the boring tools to maintain stability and minimise the entry of unwanted groundwater into the deepening borehole. In some circumstances, it may be necessary to use several different strings of casing and the more formations that are requiring sealing-off, the larger the diameter of casing that will be needed to start the borehole. Casings of 250 mm, 200 mm and 150 mm are conventional and it is the 150 mm diameter casing that is most commonly used. The technique may be used when there is a need to drill through an aquiclude into an aquifer. In these cases, the borehole is drilled in stages and at each change in casing diameter, a robust bentonite seal is placed at the base and allowed to rehydrate prior to further advancement of the borehole at the narrower diameter.

Soil samples can be taken for environmental and geotechnical purposes. "Bulk" disturbed samples can be taken from the drill cuttings and undisturbed samples can be taken using U38 or U100 sample tubes (denoting 38 mm and 100 mm diameters respectively with the latter also called U4 denoting 4 inch). In situ geotechnical tests such as SPT (Standard Penetration Tests) can also be carried out during drilling if required.

Cable percussion drilling is generally used for depths less than 40 m and typical drilling depths for ground contamination investigations are 5 m to 20 m. Significantly greater depths can be achieved from the rarer, very heavy duty, rigs.

"A" frame cable percussion rigs are fairly manoeuvrable as they are light but the length of the frame (6 m) prevents access to tight locations. Many contractors have "cut-down" mast rigs for access and operation in limited headroom locations if required. The method can generate considerable mess, particularly in soft clays and when shelling out sands and silts.

1.2 Personnel

All works are undertaken under the supervision of competent qualified personnel.

A cable percussion rig is operated by a two man crew, comprising a driller and a driller's second man.

Supervision of a cable percussive drilling contractor is carried out only by an experienced scientist/engineer that is familiar with this method of drilling and the way cable percussive drilling crews operate.

The scientist/engineer will be allocated to each rig and should be prepared to carry out or supervise closely, the majority of the "hands on" sampling of soils.

A drilling crews are BDA (British Drilling Association) accredited for cable percussive work, and have experience of working on a wide range of contaminated sites and is prepared to be flexible in terms of responding to the emerging conditions, sampling requirements, borehole design etc.

It is important that the supervising scientist/engineer double checks each measurement of borehole depth, gravel pack, bentonite seals etc.

1.3 Requirements

- Access within the site (for a towed drilling rig allow 2 m width and 12 m length;
- overhead clearance (allow 6.5 m for a rig when raised);

- available working area (allow an area of minimum 2.5 m X 6 m for the rig and the towing vehicle (usually a large four-wheel drive vehicle) will also need to have access. A general working area around the rig of is also desirable). Take into account the fact that the rig will be noisy and generate diesel fumes which may be a problem in areas confined between buildings, near public walkways etc.;

- availability of washdown facilities, with power and freshwater supply, for washing of the casing, boring tools etc. that can be accessed by the towing vehicle;

1.4 Method of Borehole Drilling

1. an appropriate location for the borehole is chosen and a "before" photograph may be taken. It may be necessary to protect the ground surface from contaminated arisings using plastic sheeting, wooden boards etc. and to use sand-bags or other methods to contain water as the borehole is drilled and arisings extracted;
2. any surface concrete is broken or cored through and a hand-dug "starter pit" may be required (e.g. to check that there are no pipes/cables etc at the drilling location). The Drill Supervisor or Second Man manoeuvres the drilling rig into position and the legs of the mast are locked into position using cross-bars at above head height. The general requirements for drilling, sampling, in situ tests and the design of the groundwater/gas monitoring installation (if needed) etc. are confirmed before the borehole is started. It is usually desirable, however for some flexibility to be maintained as the borehole is drilled and the conditions emerge;
3. a suitable boring tool is used to cut the start of the borehole and, at a suitable depth (usually less than 1 m), the first length of casing is established to which others are attached and progressively advanced as the borehole deepens;
4. as the borehole develops the scientist/engineer liaises with the drilling crew on precise sampling and groundwater measurement requirements and any in situ tests that are needed, but stands a safe distance back from and avoids obstructing the actual drilling process. Anyone approaching the rig, aside from the drilling crew, should do so only when the cable tools are at rest on the ground and all the time with an awareness of the safety of the rig itself, the equipment in the vicinity and the condition of the ground surface. All personnel should maintain a look out for anything that may affect the safety of the drilling exercise;
5. where there is need to construct the borehole in such a way as to protect, for example, an underlying aquifer the precise design is refined to reflect the emerging conditions;
6. as the borehole progresses, any retrieved spoil that is not required for samples is either stockpiled temporarily close to the borehole or placed directly into bags. Whichever method is chosen, the arisings are stored in such a way that any that are suitable can be used as backfill material at the appropriate time, while those that are not, are stored temporarily in a skip on the site and then disposed of appropriately;
7. once the desired depth is reached, final measurements of the depth of the hole and groundwater level are taken. If a groundwater/gas monitoring installation is required, this is constructed carefully by the drilling crew under instruction from the scientist/engineer and the top of the borehole fitted with an appropriate cover. Re-instatement works that are needed are carried out (arrangements for this should be made before starting the investigation);
8. irrespective of whether formal re-instatement works are to be carried out, it is important that the borehole and surrounding area are left in a safe condition. Open boreholes and drilling equipment should not be left unattended unless securely roped, coned or fenced off (safety issues are covered below).

1.5 Method of Borehole Decommissioning

If required, a borehole is decommissioned in line with the guidance contained in Environment Agency Report "Decommissioning Redundant Boreholes and Wells", insofar as it can be applied to this site.

The principal objective of the decommissioning is to remove all constituents of the standpipe installation, and to restore the soil structure to match as closely as possible its predrilled condition.

The decommissioning will follow the following sequence:

1. Removal of wellhead installation – concrete surround to cover, flush cover
2. Pull out 50mm ID HDPE – pulled from upper level and may break at intermediate joint.
3. Bore out full depth of borehole using shell and auger tools – using clean drilling techniques and commencing in 200mm diameter casings to 10mbgl and thereafter reducing to 150mm diameter through a bentonite plug. All removing standpipe sections and bentonite / gravel surround will be removed in the boring process
4. Restore lithology in the borehole by the initial placement of clean imported non limestone 20mm single size gravel, from the base of the borehole. The casing will be progressively pulled to allow the gravel to occupy the borehole volume. The placement of the gravel will be followed by the ramming in of boulder clay at the base of the borehole as the casing is further progressively withdrawn (clay recovered from offsite borehole source). The borehole will then be restored to ground level by the placement of non limestone pea gravel. The site will be restored by topsoil and seeding.
5. All arisings from the borehole will be bagged and transported offsite for disposal at a licensed landfill.

2.0 DYNAMIC SAMPLING

2.1 Description of Plant

Window sampling is a percussive method of creating small diameter boreholes. Mostly the technique is achieved using hand-held equipment but some small drilling rigs have the capacity for window-sampling and the power of the rig enables window samplers to be driven to, and extracted from, greater depths compared to the manual technique.

A window sampler is a high tensile steel tube with a hardened cutting shoe to penetrate hard materials. Each sampler is usually 1 m or 2 m long with a series of "windows" or slots cut in the wall of the tube through which to view or extract soil samples. Samplers are driven down into the ground using a percussive hammer. A full set of window samplers usually consists of around four samplers ranging in diameter from 80 mm down to 35 mm. These are used systematically, starting with the widest and subsequently at reducing diameter to the required depth or limit of the technique. The depth limit tends to be around 8 m to 10 m although the technique is usually used to a maximum depth of around 5 m. In practice, the limiting factor tends not to be how deep the samplers can be driven in but rather whether the ground conditions are such that they may then be pulled back out. Coarse dense gravels, in particular, can grip the samplers and make extraction extremely difficult. The driller will assess the conditions at each location individually.

The start diameter is dictated by the ground conditions i.e. the softer the conditions, the wider the sampler set that can be driven in. Typically, however, a 60 mm to 80 mm diameter start sampler will be used, reducing to around 35 mm by around 4 m to 5 m depth. The full samplers are either jacked out manually or pulled from the hole using a hydraulic jacking system.

A full sampler will reveal a complete or partial ground profile although guidance from the driller will be needed on any compression that may have occurred and resulted in, for example, a 1.5 m sample occupying a 1 m space in the sampler. With some window sampling systems, samples can be recovered in a thin walled transparent liner placed inside the steel tubes. The liner is removed for visual inspection or capped at each end for transporting to the laboratory. Whatever system is used, the quantity of soil within the sampler is small and, particularly where the analytical suite is extensive, a sample may have to be taken from a 0.5 m or so section to ensure sufficient quantity. The advantage, however, is that once soil is taken for samples and backfilling purposes, there is rarely any excess requiring disposal.

Narrow diameter groundwater/gas monitoring installations can be constructed in the borehole once all samplers are withdrawn. Whilst the diameter of the standpipe is ultimately dictated by the diameter of the smallest (and lowest positioned) sampler, in practice it is usually possible to install a 19 mm or 35 mm standpipe with a fine gravel pack surround. With some systems, it is possible to drive a water well in through unsampled ground using the hammer unit.

This method is not suitable where there is a need to drill through an aquiclude into an aquifer as there is no way of protecting the aquifer from downwards migration of any contaminants from the ground above the aquiclude during drilling.

The equipment is generally brought to site in a van or four-wheel drive vehicle and from then on, it can be carried by hand around the site. In many circumstances the fact that this is largely a manual method is its advantage over even the smallest drilling rigs. Window sampling causes minimal disturbance to the ground surface (e.g. useful for investigations inside buildings, in a landscaped car park or between the sleepers of rail lines. The method can be used where access is very restricted (e.g. small operational sites and in gardens). It can also achieve rapid coverage to shallow depth (e.g. useful for establishing the thickness of a landfill cap over a large area).

2.2 Personnel and Equipment on Site

Two window sampler will be operated by an experienced driller. Operatives will be provided with safety boots, approved HV jackets/coats, hard hats, safety goggles, disposable coveralls, disposable gloves, ear protection and dust/vapour masks, which will be used where appropriate. There will also be various portable tools on site, such as a breaker, spades, tapes, hand tools such as screwdrivers, wrenches. In addition, small amounts of diesel fuel will also be present on site.

2.3 Method of Dynamic Sampling

Sequence of events is as follows:

• an appropriate location for the window sampler borehole ("the borehole") is chosen and a 'before' photograph may be taken. Any surface concrete is broken or cored through. It is usually unnecessary to protect the ground surface as the method generates hardly any mess. However, if needed, samplers can be placed on plastic sheeting during sampling to protect particularly sensitive ground surfaces.

• the general requirements for drilling, sampling, in situ tests and the design of the groundwater/gas monitoring installation (if needed) etc. are confirmed before the borehole is started. It is usually desirable, however for some flexibility to be maintained as the borehole is drilled and the conditions emerge;

• the first, and widest, sampler is driven fully into the ground and withdrawn. The next narrower one is pushed through the open hole to its base and then driven, in turn, into the soil at the bottom. This sequence is repeated using progressively smaller diameter samplers down to the required depth or limit of the technique in the particular ground conditions encountered;

• as the borehole develops the scientist/engineer liaises with the drilling crew on precise sampling and groundwater measurement requirements, but avoids obstructing the actual drilling and jacking out processes. All personnel maintain a look out for anything that may affect the safety of the drilling exercise;

• if there is spoil in excess of that needed for sampling/backfilling purposes, this is placed directly into bags and stored in such a way that they may be disposed of appropriately once the investigation has finished;

• once the desired depth is reached, a groundwater/gas monitoring installation is constructed carefully by the driller (if required) and the top of the borehole fitted with an appropriate cover. If an installation is not needed, the hole is backfilled with clean suitable material. This can be any spoil in excess of that required for sampling (if suitable), clean sand/gravel (if appropriate) or bentonite to prevent future downward migration of contaminants through the hole;

• On many sites it is unlikely that any re-instatement works will be needed. If they are (e.g. concrete/tarmac repair), these are carried out (arrangements for this should be made before starting the investigation). The borehole and surrounding area must be left in a safe condition. Drilling equipment should not be left unattended, not least due to its portability (safety issues are covered below).

2.4 Operational Requirements

- access to and within the site – window sampling is a method that is particularly suited to sites where access is very constrained and inaccessible for other drilling methods. Essentially, a window sampler borehole can be drilled if there is space for two people and equipment the size of a small suitcase held initially just above head height. In exceptionally small spaces, the equipment can be operated by one person but this is not ideal;
- overhead clearance - similarly, the overall height of the equipment tends to be less than for many other drilling methods (allow 2.5 m);
- available working area -see notes above (while a borehole can be drilled very small spaces, if possible, allow a working area of around 2 m by 3 m to accommodate the drilling operations, the samplers on the ground and ancillary equipment). The hammer unit will generate noise similar to that of lawnmower and this should be considered when working in locations close to members of the general public;
- availability of washdown facilities, with power and freshwater supply, for washing of the samplers etc. (can be accessed on foot);
- knowledge of the location of buried services is essential for the safety of the drilling crew.

3.0 TRIAL PIT EXCAVATIONS

3.1 Description of Plant

Trial pits are usually excavated using a JCB 3CX excavator/backactor. However, if ground conditions are suspected to be more difficult or the trial pits are expected to exceed 5.0m, a light tracked excavator (weighing up to 14 tonnes) may be used.

If a JCB 3CX excavator is used it will be driven to site by the operator.

If a tracked excavator is to be used, it will be transported to/from site on a low loader. The machine will be off loaded under the supervision of a banksman, and the machine will track onto the site. All movements and excavations made on site will be under the supervision of a banksman and engineer.

3.2 Description of Method

Trial pits are exploratory holes excavated into the ground by hand or by mechanical excavator. Compared to boreholes, trial pits allow faster inspection of a larger proportion of the groundmass and are a means of obtaining larger quantities of soil samples. Trial pits can be used to obtain groundwater samples if conditions are such that sufficient can collect in the base of the pit in the time available, without risk of ground instability and if samples obtained in this way are technically suitable for the purposes of the investigation. Trial pits can also provide a means of installing rudimentary gas monitoring standpipes to supplement ones constructed in boreholes.

Trial pits can be excavated to a variety of sizes to suit the requirements of the investigation e.g. narrow and very deep to investigate within a landfill or a series of shallow and long "trial trenches" to establish the extent of an infilled area. However the typical size of a trial pit is around 2 m long by 0.5 m – 1m wide by up to 5 deep. Trial pits can be hand dug to 1.2 m, but the usual method is to use hired mechanical plant with a skilled operator. The plant most commonly used is a wheeled backhoe loader (using the backactor arm) which is frequently referred to as a "JCB", irrespective of the actual make. With a conventional digging arm these can achieve depths of around 3.5 m and with an extendable arm they can achieve depths around 5 m. Other types of excavators can be used to suit certain situations. For example, a slew boom hydraulic excavator may gain access to areas too constrained for a backhoe loader. Where there is a high risk that the ground surface will cause puncture to vehicle tyres (for which the hirer pays) then tracked, rather than wheeled, excavators may be more suitable. Tracked vehicles can also be useful where it is desirable to spread weight on soft ground. However, these vehicles have to be brought to site on a low-loader. Very large machines can be hired to excavate pits deeper than 5 m. The condition of machines varies considerably and old machines and those that have been used for more than an average amount of breaker work (for breaking through concrete and other hard layers) may be considerably slower and risk of break down is greatly increased. This can seriously impact on a site investigation programme.

The width of a mechanically excavated trial pit is dictated by the size of excavator used. Wider buckets (around 1 m) allow inspection of a larger proportion of the ground but generate very large volumes of spoil and, where concrete is present on the ground surface, require more time to be spent breaking through. Narrow buckets (around 0.5 m) create less ground disturbance but it can be difficult to see the pit walls at depths below around 4 m. A bucket size between these two extremes is usually appropriate. Breaker units vary in size and, particularly, in condition. It is usual to specify precise requirements to the plant hire company.

The operating arm and connecting parts of all excavators need considerable lubrication during the working day. An awareness of this on the part of the supervising scientist/engineer is necessary, particularly during sampling activities. In addition, it is common practice for finished tubes of lubricant to be discarded on the ground or even into trial pits before backfilling. The unacceptability of this may need to be stressed to the excavator driver at the outset of the investigation.

3.3 Sequence of Events

- an appropriate location (clear of underground services etc) for the trial pit is chosen and a "before" photograph may be taken. It may be necessary to protect the ground surface from contaminated arisings using plastic sheeting, wooden boards etc. and to use sand-bags or other methods to contain water as the pit is dug;
- the excavator driver manoeuvres the excavator into a suitable position for the trial pit location, taking into account factors such as the position of the sun/other bright lights (good visibility is essential) and wind direction (in relation to vehicle exhaust fumes, ground gases, odours etc). Any surface concrete/other hard cover is broken out to a suitable size and the excavator changes from breaker to bucket. As the trial pit is dug, the scientist/engineer directs the speed/depth of excavation and also maintains a constant look out for anything that may affect safety of the trial pitting exercise. Under no circumstances should anyone enter a trial pit;

- as the trial pit progresses, the spoil is segregated in such a way that it can be used to backfill the pit in roughly the same order that it was removed. Photographs, depth measurements and samples are taken as required (during this time the excavator stands still with the bucket on the ground i.e. hydraulics at rest). Anyone approaching a trial pit should do so on the short side opposite the excavator and all the time with an awareness of the pit's stability and the surrounding ground conditions. (see section below on practical safety and environmental protection measures about safe distances for placement of excavated spoil, safe working near trial pits etc.).

- once the desired depth or limit of the machine is reached, final measurements and photographs are taken (the driver should not be asked to hold the photograph identification board). The trial pit is then backfilled using the original spoil which is emplaced in roughly the same order to the original (alternatively, clean sand/gravel may be used). A gas monitoring standpipe may be installed in the trial pit. When backfilling is completed, an "after" photograph may be taken; re-instatement works that are needed are carried out (arrangements for this should be made before starting the investigation). Irrespective of whether formal re-instatement works are to be carried out, it is important that the backfilled trial pit and surrounding affected area are left in a safe condition. Open trial pits should NEVER be left unattended unless securely fenced off (safety issues are covered below).

3.4 Personnel and Equipment on Site

In addition to the machine operator the crew will comprise of a banksman to oversee machine movements, fix and relocate temporary safety barriers, ensure that reinstatements are safe pending final paving etc, and an engineer to direct the positioning of the pits, log the exposures and undertake soil sampling and PID scanning.

Other requirements are:

- Access to the site and within the site (for a backhoe loader allow 2.7 m width for access through gates and more for larger machines – check with the plant hire company);
- overhead clearance (allow 6.5 m for a backhoe loader and more for larger machines);

- available working area (allow an area of minimum 15 m X 15 m for a backhoe loader and more for larger machines);

- availability of washdown facilities, with power and freshwater supply, for the excavator bucket that can be accessed by the excavator;

- ability of ground to support weight of plant (a backhoe loader weighs around 9 tonnes while larger machines can weigh 45 tonnes).

3.5 Method of Trial Pit Excavation

Each proposed trial pit location will be positioned to be clear of all services shown on record drawings. The absence of services on drawing records for the proposed positions will not be basis for presumption that the locations are service free. Each location will be scanned by CAT service locator before and continuously during the excavation.

Materials will be carefully excavated from each trial pit in thin layers, and the arisings stockpiled adjacent to the excavation. On encountering each new stratum the excavation will be stopped, while physical measurements and, where relevant, soil samples taken. Soil samples will be collected in polythene tubs and amber glass jars, which will be sealed and labelled before shipment to the laboratory. If groundwater is encountered, then excavations will be stopped while physical measurements and groundwater samples are taken in amber glass bottles.

All trial pits will be backfilled immediately after excavation, with the materials being replaced as far as possible in the reverse order to which they have been excavated.

Excavated materials will be thoroughly tamped as each layer is placed to produce a dense reinstatement matching, as near as possible, the profile of the surrounding ground. Excess spoil (if any), will be removed offsite for disposal.

Soil, Water and Gas Sampling/Monitoring Methodologies

Sampling Of Soil For Contamination Assessments

Soil samples are recovered in contamination site investigations from either dynamic sampling boreholes or trial pits.

Sampling equipment (steel casing tubes, spatulas etc) is cleaned using water between sample positions to avoid cross contamination. Gloves are changed on completion of each sampling location)

Dynamic Sampling Boreholes

Samples are recovered in relatively undisturbed 1m long plastic tubes. Once extracted the tube is immediately split and logged. Samples are taken from each strata and from 0.1mbgl, 0.45mbgl, and 1.0mbgl. The number/locations of samples to be analysed will be made on completion of the fieldwork. Duplicate subsamples are taken and headspace analyses by PID (to the methodology in CIRIA C665 – given below) is undertaken. This data will be used to target VOC analyses.

Samples are stored in an electric cool box with ice packs.

Trial Pits

Samples are taken from the bucket of an excavator and placed in airtight containers. Each container is uniquely labelled with the Project No / Trial Pit No / Depth increment/ Date Sampled. The samples are then immediately placed in an electric cool box chilled by ice packs, and the boxes are sealed for transportation to the laboratory.

Sampling Containers

Subsamples from boreholes or samples from trial pits comprise of a 1kg plastic tub and a 500g amber glass jar. When possible, samples will be collected from the site, and if this is not possible samples will be transported to the regional office and stored in a refrigerator until collection. Samples are packaged with ice packs immediately prior to transit.

Chain Of Custody Records

A Chain of Custody Record (CoC) is sent with the batch of samples. A copy of the CoC is also emailed to the laboratory prior to sample delivery. ***A copy of the CoC is included with the analyses certificates.***

Headspace Analyses

Duplicate subsamples of ALL samples selected for laboratory analysis, are taken for headspace analyses, using a Photo Ionisation Detector (PID). In the test method, an amber glass jar is half filled with soil, and the lid is sealed with aluminium foil secured by an elastic band. The jar and contents are agitated for 30 seconds and left for a minimum of 30 minutes out of direct sunlight for the headspace to achieve equilibrium. The PID then pierces the seal and the maximum reading is recorded. This provides a qualitative method which results in a representation of the presence of volatile organic compounds in the soil. The numerical output cannot be directly compared to measured soil concentrations of CoC.

The prevailing weather conditions, and ambient temperature are also recorded.

The PID headspace results are recorded on the exploratory borehole or trial pit logs.

Laboratory VOC analyses will be obtained where the PID headspace data indicate a potential presence of volatiles.

Sampling Of Water in Standpipes

Water is sampled from standpipes installed during borehole drilling. On completion of the construction of the standpipe, the installation is developed by removing approximately 10 x the internal volume of the installation. The volume of water removed is recorded. The standpipe is then left for a week for hydraulic equilibrium to be restored.

Prior to sampling the standpipe, the depth to the water table, and the depth to the base of the standpipe are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.

A minimum of 3 x the standpipe volume is then removed. The pH of the water is then monitored and the sample is taken when the change in pH between any two consecutive standpipe extracts is less than 10%. The volume of water removed is recorded.

A sample comprises of a minimum of 3 litres. Two litres are taken in amber glass bottles, and one litre in a plastic bottle.

To avoid cross-contamination one bailer is used per position.

The samples are uniquely labelled with Project Name / Project No / Borehole No / Depth / Date Sampled. They are placed in a cool box chilled by ice packs, and the containers are sealed for transportation to the laboratory.

Once the samples are received in the ***DEMETER ENVIRONMENTAL*** laboratory, the samples are stored in a refrigerator and returned to the cool boxes once collected.

Other data recorded in the sampling comprises:

- Volume of water removed during development of well
- Volume of water removed during purging of the well
- Results of on-site pH analyses
- Sample appearance – colour, suspended solids

Monitoring Of Gas

Prior to embarking on a gas-monitoring round, all equipment is checked for functionality and the calibration status is confirmed. Barometric pressure of the site (based on nearest Met Office station or other weather station) will be recorded thought the monitoring regime and monitoring visits will be undertake, where practicable, during periods of falling barometric pressure.

At the commencement of the monitoring round, the prevailing weather conditions, air temperature, barometric pressure and direction of movement of barometric pressure are recorded.

The flow meter is first attached to the standpipe valve, and the flow rate is measured (peak and steady flow) for 1 minute. The results are recorded in $l.hr^{-1}$.The flow meter tube is protected from the effects of wind by aligning the exhaust downwind.

Following measurement of borehole flow rate, the installation is left for a minimum of 10 minutes for the headspace to restore equilibrium.

Once the gas in the installation has regained equilibrium, the gas analyser is connected and monitoring commences. The peak and steady state readings for CH_4, CO_2, CO, H_2S and CO are recorded. The steady state is monitored for a minimum of one minute, and possibly up to a maximum of 10 minutes where fluctuations continue.

When the monitoring is complete, the depth to the water table, and the depth to the base of the well are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.

Decontamination of Equipment

Decontamination of equipment was carried out at appropriate times throughout the site work in order to minimise the potential for cross-contamination of materials. Equipment decontamination measures were performed in the field between each sampling location and prior to equipment storage on completion of the work.

Drilling decontamination incorporated the cleaning of equipment using a brush to remove particulate matter and surface film while sampling equipment decontamination incorporated equipment rinsing and cleaning with potable tap water.

Collection, Preservation and Transport of Samples

Soil- Environmental

Samples to be analysed for organic compounds were collected and sealed in glass jars. In order to prevent the loss of volatile organic compounds, the air space was kept to a minimum by filling the jars as far as reasonably practicable. Samples to be analysed for metals were collected in plastic containers.

Disposable gloves were worn and changed between each sample taken to prevent cross contamination. The soil samples were stored in a cool box with ice packs and dispatched to the laboratory on the day of collection where possible. All sample details were recorded on the laboratory chain of custody documentation.

Soil- Geotechnical

The undisturbed geotechnical samples were collected in appropriate liners and were sealed on site to prevent the loss of moisture. The disturbed samples were placed in sealed and correctly labelled plastic tubs or bags as appropriate. All geotechnical samples were dispatched to the geotechnical laboratory for testing with a completed chain of custody.

Water

Glass jars and vials were used for the collection of all groundwater samples to be analysed for organic compounds. Containers for volatile analysis were filled so that minimal air space remained prior to sealing the container. This, in combination with a low storage temperature, ensures that volatile compounds that may have been present within the sample were not lost to the headspace prior to analysis.

The water samples were stored in a cool box with ice packs and dispatched to the laboratory on the day of collection. All sample details were recorded on the laboratory chain of custody documentation.

APPENDIX E: SUMMARY OF TIER 1 THRESHOLDS

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
METALS, SEMI-METALS AND NON-METALS					
Arsenic (inorganic)	7440-38-2	37	49	640	C4SL
		37	43	640	LQM S4UL
Barium	7440-39-3	1,300	2,500	22,000	EIC
Beryllium	7440-41-7	1.7	35	12	LQM S4UL
Cadmium (calculated using lifetime exposure)	7440-43-9	22	4.9	410	C4SL
		11	1.9	190	S4UL
Chromium III	7440-47-3	910	18,000	8,600	LQM S4UL
Copper	7440-50-8	2,400	520	68,000	LQM S4UL
Lead	7439-92-1	200 (C4SL)	80 (C4SL)	2300 (C4SL)	C4SL
Elemental Mercury	7439-97-6	1.2	21	25.8	LQM S4UL
Inorganic Mercury	7487-94-7	40	19	1,100	LQM S4UL
Methyl Mercury	115-09-3	11	6	320	LQM S4UL
Molybdenum	7439-98-7	640	1,000	17,000	EIC
Nickel	7440-02-0	180	53	980	LQM S4UL
Selenium	7782-49-2	250	88	12,000	LQM S4UL
Thallium	7440-28-0	6.0	7.9	130	In house threshold
Vanadium	7440-62-2	410	91	9,000	LQM S4UL
Zinc	7440-66-6	3,700	620	730,000	LQM S4UL
Complexed Cyanide	74-90-8	230	230	1,300	In house threshold
Free Cyanide	74-90-8	22	22	120	In house threshold
Antimony	7440-36-0	600	1,300	7,400	EIC
Chromium VI	18540-29-9	21	170	49	C4SL
		6	1.8	33	LQM S4UL
Boron	7440-42-8	290	45	240,000	LQM S4UL
BTEX Compounds					
Benzene	71-43-2	0.87	0.18	140	C4SL
		0.087	0.017	27	LQM S4UL
Toluene	108-88-3	130	22	869	LQM S4UL
Ethyl Benzene	100-41-4	47	16	518	LQM S4UL
o – Xylene	106-42-3	60	28	478	LQM S4UL
m – Xylene	108-38-3	59	31	625	LQM S4UL
p – Xylene	95-47-6	56	29	576	LQM S4UL
Merhyl Tert-Butyl Ether	1634-04-4	210	89	22,000	EIC
PAH'S (USEPA 16)					
Naphthalene	91-20-3	2.3	4.1	76.4	LQM S4UL
Acenaphthylene	208-96-8	170	28	86.1	LQM S4UL
Acenaphthene	83-32-9	210	34	57	LQM S4UL
Fluorene	86-73-7	170	27	30.9	LQM S4UL
Phenanthrene	85-01-8	95	15	22,000	LQM S4UL
Anthracene	120-12-7	2,400	380	520,000	LQM S4UL
Fluoranthene	206-44-0	280	52	23,000	LQM S4UL
Pyrene	85-01-08	620	110	54,000	LQM S4UL
Benz(a)anthracene	56-55-3	7.2	2.9	170	LQM S4UL
Chrysene	218-01-9	15	4.1	350	LQM S4UL
Benzo(b)fluoranthene	205-99-2	2.6	0.99	44	LQM S4UL
Benzo(k)fluoranthene	207-08-9	77	37	1,200	LQM S4UL
Benzo(a)pyrene	50-32-8	2.2	0.97	35	LQM S4UL
Indeno(123-cd)pyrene	193-39-5	27	21	500	LQM S4UL
Dibenz(ah)anthracene	53-70-3	0.24	0.14	3.5	LQM S4UL
Benzo(ghi)perylene	191-24-2	320	290	3,900	LQM S4UL

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
HYDROCARBONS (TPHCWG)					
Aliphatic EC5-EC6	N/A	42	730	304	LQM S4UL
Aliphatic EC6-EC8	N/A	100	2,300	144	LQM S4UL
Aliphatic EC8-EC10	N/A	27	320	78	LQM S4UL
Aliphatic EC10-EC12	N/A	48	2,200	48	LQM S4UL
Aliphatic EC12-EC16	N/A	24	11,000	24	LQM S4UL
Aliphatic EC16-EC35	N/A	65,000	260,000	1,600,000	LQM S4UL
Aliphatic EC35-EC44	N/A	65,000	260,000	1,600,000	LQM S4UL
Aromatic EC5-EC7	N/A	70	13	1,220	LQM S4UL
Aromatic EC7-EC8	N/A	130	22	869	LQM S4UL
Aromatic EC8-EC10	N/A	34	8.6	613	LQM S4UL
Aromatic EC10-EC12	N/A	74	13	364	LQM S4UL
Aromatic EC12-EC16	N/A	140	23	169	LQM S4UL
Aromatic EC16-EC21	N/A	260	46	28,000	LQM S4UL
Aromatic EC21-EC35	N/A	1,100	370	28,000	LQM S4UL
Aromatic EC35-EC44	N/A	1,100	370	28,000	LQM S4UL
EC44-70	N/A	1,600	1,200	28,000	LQM S4UL

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
VOC's					
Heptane	142-82-5	No data	No data	No data	N/A
Octane	111-65-9	No data	No data	No data	N/A
Nonane	111-84-2	No data	No data	No data	N/A
Benzene	71-43-2	0.87	0.18	140	C4SL
		0.087	0.017	27	LQM S4UL
Toluene	108-88-3	130	22	869	LQM S4UL
Ethyl Benzene	100-41-4	47	16	518	LQM S4UL
m+p – Xylene	106-42-3	56	29	41,000	LQM S4UL
o – Xylene	95-47-6	60	28	478	LQM S4UL
1, 2-Dichloroethene-cis	156-59-2	0.16	0.017	14	EIC
1, 1-Dichloroethane	75-34-3	3.4	0.26	260	EIC
Chloroform	67-66-3	0.91	0.42	99	LQM S4UL
Tetrachloromethane (Carbon tetrachloride)	56-23-5	0.026	0.45	2.9	LQM S4UL
1, 1, 1-Trichloroethane	71-55-6	8.8	48	660	LQM S4UL
Trichloroethylene	79-01-6	0.016	0.041	1.2	LQM S4UL
Tetrachloroethylene	127-18-4	0.18	0.65	19	LQM S4UL
1, 1, 1, 2-Tetrachloroethane	630-20-6	1.2	0.79	110	LQM S4UL
1, 1, 2, 2-Tetrachloroethane	79-34-5	1.6	0.41	270	LQM S4UL
Chlorobenzene	108-90-7	1.2	5.9	56	LQM S4UL
Bromobenzene	108-86-1	6.6	3.2	92	EIC
Bromodichloromethane	75-27-4	0.022	0.016	2.0	EIC
Methylethylbenzene	92-82-8	No data	No data	No data	N/A
1, 1-Dichloro-1-propene	563-58-6	No data	No data	No data	N/A
Trans-1,2-dichloroethylene	156-60-5	No data	No data	No data	N/A
2, 2-Dichloropropane	594-20-7	No data	No data	No data	N/A
Bromochloromethane	74-97-5	No data	No data	No data	N/A
1, 2-Dichloroethane	107-06-2	0.0071	0.0046	0.67	LQM S4UL
Dibromomethane	74-95-3	No data	No data	No data	N/A
1, 2-Dichloropropane	78-87-5	0.034	0.62	3.1	EIC
cis- 1, 3-Dichloro-1-propene	542-75-6	No data	No data	No data	N/A
trans- 1, 3-Dichloro-1-propene	99614-02-5	No data	No data	No data	N/A
1, 1, 2-Trichloroethane	79-00-5	3.38	9.2	260	EIC
Dibromochloromethane	124-48-1	0.075	0.57	4.7	Demeter
1, 3-Dichloropropane	142-28-9	No data	No data	No data	N/A
1,2-dibromoethane	106-93-4	No data	No data	No data	N/A
Styrene	100-42-5	8.7	1.6	63	EIC
Propylbenzene	103-65-1	No data	No data	No data	N/A
2-Chlorotoluene	95-49-8	3.7	4.3	280	Demeter
1, 2, 4-Trimethylbenzene	95-63-6	0.74	0.38	39	EIC
4-Chlorotoluene	106-43-4	No data	No data	No data	N/A
t-Butylbenzene	98-06-6	No data	No data	No data	N/A
1,3,5-trimethylbenzene	108-67-8	ND	ND	ND	EIC
1-Methylpropylbenzene	68411-44-9	No data	No data	No data	N/A
o-Cymene	527-84-4	No data	No data	No data	N/A
1, 4-Dichlorobenzene	106-46-7	61	15	224	LQM S4UL
Butylbenzene	104-51-8	ID	ID	ID	EIC
1, 2-Dibromo-3-chloropropane	96-12-8	No data	No data	No data	N/A
Hexachlorobutadiene	87-68-3	0.29	0.25	31	N/A
1, 2, 3-Trichlorobenzene	87-61-6	1.5	4.7	102	LQM S4UL
Naphthalene	91-20-3	2.3	10	76.4	LQM S4UL
1, 2, 4-Trichlorobenzene	120-82-1	2.6	55	15,000	LQM S4UL
1, 4-Dichlorobenzene	541-73-1	No data	No data	No data	N/A
1, 2-Dichlorobenzene	90-50-1	23	94	571	LQM S4UL
Bromoform	75-25-2	3.4	0.95	710	EIC
Chloroethene (Vinyl Chloride)	75-01-4	0.00064	0.00055	0.059	LQM S4UL
1,2,3,4-Tetrachlorobenzene	636-66-2	15	4.4	122	LQM S4UL
1,2,3,5-tetrachlrobenzene	634-90-2	0.66	0.38	39.4	LQM S4UL
1,2,4,5-Tetrachlorobenzene	95-94-3	0.33	0.06	19.7	LQM S4UL
Pentachlorobenzene	608-93-5	5.8	1.2	43.0	LQM S4UL
Carbon Disulphide	75-15-0	0.14	4.8	11	LQM S4UL
VOC's					
1,1-Dichloroethene	75-34-3	0.23	2.8	26	EIC

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
Chloroethane	75-00-3	8.3	110	950	EIC
Chloromethane	74-87-3	0.0083	0.066	1.0	EIC
Dichloromethane	75-09-2	0.58	0.10	270	EIC
1, 3, 5-Trichlorobenzene	120-82-1	0.33	4.7	23	LQM S4UL
Hexachlorobenzene	118-74-1	0.20	0.47	0.20	LQM S4UL
SVOC's					
Phenol	108-95-2	280	66	760	S4UL
Aniline	62-53-3	No data	No data	No data	N/A
Bis(2-chloroethyl)ether	111-44-4	No data	No data	No data	N/A
2-Chlorophenol (sum of all chlorophenols)	95-57-8	0.87	0.13	3,500	S4UL
1,3-Dichlorobenzene	541-73-1	0.40	0.25	30	S4UL
1,4-Dichlorobenzene	106-46-7	61	15	224	S4UL
Benzyl Alcohol	100-51-6	No data	No data	No data	N/A
1,2-Dichlorobenzene	95-50-1	23	94	570	S4UL
2-Methylphenol	95-48-7	82	64	15,000	EIC
Bis(2-chloroisopropyl)ether	100-60-1	No data	No data	No data	N/A
3 and 4-methylphenol	108-39-4 106-44-5	81	63	26,000	EIC
N-Nitrosodi-n-propylamine	621-64-7	No data	No data	No data	N/A
Hexachloroethane	67-72-1	0.27	1.6	8.2	EIC
Nitrobenzene	98-95-3	No data	No data	No data	N/A
Isophorone	78-59-1	No data	No data	No data	N/A
2-Nitrophenol	88-75-5	No data	No data	No data	N/A
2,4-Dimethylphenol	105-67-9	19	17	1,400	EIC
Bis(2-chloroethoxy)methane	111-91-1	No data	No data	No data	N/A
2,4-Dichlorophenol (sum of all chlorophenols)	120-83-2	0.87	0.13	3,500	S4UL
1,3,5-Trichlorobenzene	108-70-3	0.33	4.7	23	S4UL
3-Chloroaniline	108-42-9	No data	No data	No data	N/A
Hexachloro-1,3-butadiene	87-68-3	0.29	0.25	31	S4UL
4-Chloro-3-methylphenol	59-50-7	No data	No data	No data	N/A
2-Methylnaphthalene	91-57-6	ND	ND	ND	EIC
1-Methylnaphthalene	90-12-0	ND	ND	ND	EIC
Hexachlorocyclopentadiene	77-47-4	No data	No data	No data	N/A
2,4,6-Trichlorophenol (sum of all chlorophenols)	88-06-2	0.87	0.13	3,500	S4UL
2,4,5-Trichlorophenol (sum of all chlorophenols)	58-90-2	0.87	0.13	3,500	S4UL
1-Chloronaphthalene	90-13-1	No data	No data	No data	N/A
2-Nitroaniline	88-74-4	No data	No data	No data	N/A
1,4-Dinitrobenzene	100-25-4	No data	No data	No data	N/A
Dimethyl phthalate	113-11-3	ND	ND	ND	EIC
1-3-dinitrobenzene	99-65-0	No data	No data	No data	N/A
2-6-dinitrotoluene	606-20-2	0.79	0.61	1,800	EIC
1,2-Dinitrobenzene	528-29-0	No data	No data	No data	N/A
3-Nitroaniline	99-09-2	No data	No data	No data	N/A
4-nitrophenol	100-02-7	No data	No data	No data	N/A

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
Dibenzofuran	132-64-9	No data	No data	No data	N/A
2,3,5,6-Tetrachlorophenol (sum of all chlorophenols)	935-95-5	0.87	0.13	3,500	S4UL
2,3,4,6-Tetrachlorophenol (sum of all chlorophenols)	58-90-2	0.87	0.13	3,500	S4UL
Diethyl phthalate	84-66-2	120	94	13	EIC
1-chloro-4-phenoxybenzene	6452-49-9	No data	No data	No data	N/A
4-Nitroaniline	100-01-6	No data	No data	No data	N/A
Dinitro-o-cresol	497-56-3	No data	No data	No data	N/A
Diphenylamine	122-39-4	No data	No data	No data	N/A
Azobenzene	103-33-3	No data	No data	No data	N/A
1-bromo-4-phenoxybenzene	101-55-3	No data	No data	No data	N/A
Hexachlorobenzene	118-74-1	No data	No data	No data	N/A
Pentachlorophenol	87-86-5	0.22	0.03	400	S4UL
Carbazole	86-74-8	ND	ND	ND	EIC
Dibutyl phthalate	84-74-2	No data	No data	No data	N/A
Butyl benzyl phthalate	85-68-7	1,400	1,300	94,000	EIC
Bis-2-ethylhexyladipate	103-23-1	No data	No data	No data	N/A
Butyl benzyl phthalate	85-68-7	1,400	1,300	94,000	EIC
Bis(2-ethylhexyl)phthalate	17-81-7	290	280	85,000	EIC
PESTICIDES					
alpha-Lindane	319-84-6	0.23	0.035	170	LQM S4UL
beta_Lindane	319-85-7	0.085	0.013	65	LQM S4UL
gamma-Lindane	58-89-9	0.06	0.0092	67	LQM S4UL
delta-Lindane	319-86-8	No data	No data	No data	N/A
Heptachlor	76-44-8	No data	No data	No data	N/A
Aldrin	309-00-2	5.7	3.2	170	LQM S4UL
Heptachlor expoxide	1024-57-3	0.072	0.036	2.2	Demeter
trans-Chlordane	5103-74-2	No data	No data	No data	N/A
alpha cis-Chlordane	5103-71-9	No data	No data	No data	N/A
p,p-DDE	82413-20-5	No data	No data	No data	N/A
Dieldrin	60-57-1	0.97	0.17	170	LQM S4UL
Endrin	72-20-8	1.6	0.51	190	Demeter
p,p-DDD	72-54-8	30	46	480	Demeter
Endosulfan II	33213-65-9	7.0	1.1	6,300	LQM S4UL
Endrin aldehyde	72-20-8	No data	No data	No data	N/A
p,p-DDT	50-29-3	20	12	480	Demeter
Endosulphan sulphate	1031-07-8	No data	No data	No data	N/A
Methoxychlor	72-43-5	No data	No data	No data	N/A
Methamidophos	10265-92-6	No data	No data	No data	N/A
Dichlorvos	62-73-7	No data	No data	No data	N/A
Acephate	20560-19-1	No data	No data	No data	N/A
Omethoate	1113-02-6	No data	No data	No data	N/A
Demeton-s-methyl	919-86-8	No data	No data	No data	N/A

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	
Dimethoate	60-51-5	No data	No data	No data	N/A
Tolclofos-methyl	57018-04-9	No data	No data	No data	N/A
Pirimifos-methyl	29232-93-7	No data	No data	No data	N/A
Malathion	121-75-5	No data	No data	No data	N/A
Chlorpyrifos	2921-88-2	No data	No data	No data	N/A
Mathidathion	950-37-8	No data	No data	No data	N/A
Tokuthion	34643-46-4	No data	No data	No data	N/A
Profenofos	41198-08-7	No data	No data	No data	N/A
Ethion	563-12-2	No data	No data	No data	N/A
Aziniphos-methyl	86-50-0	1.7	0.48	4,800	Demeter
Pyrazophos	13457-18-6	No data	No data	No data	N/A
EXPLOSIVES					
Nitroglycerine (NG)	55-63-0	No data	No data	No data	N/A
Ethylene glycol dinitrate (EGDN)	628-96-6	No data	No data	No data	N/A
2,4,6-trinitrotoluene (TNT)	118-96-7	1.6	0.24	1,000	S4UL
Cyclotetramethylenetetranitramine (HMX)	2691-41-0	5.7	0.86	110,000	S4UL
Cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX)	121-82-4	120	17	210,000	S4UL
Picrite	556-88-7	No data	No data	No data	N/A
2,4,6-trinitrophenol (picric acid)	88-89-1	No data	No data	No data	N/A
N-methyl-N,2,4,6-tetranitroaniline (tetryl)	479-45-8	No data	No data	No data	N/A
Hexanitrostilbene (HNS)	20062-22-0	No data	No data	No data	N/A
Pentaerythritol tetranitrate (PETN)	78-11-5	No data	No data	No data	N/A
2,4-dinitrotoluene	121-14-2	1.5	0.23	3,700	EIC
2,6-dinitrotoluene	606-20-2	0.79	0.12	1,900	EIC
Nitrocellulose (NC)	9004-70-0	No data	No data	No data	N/A

Summary of Demeter Environmental Tier 1 GAC's for a Soil Organic Matter of 1% (6% for C4SL's)

Contaminant	CASN	GAC / C4SL (mg/kg)			Source of Data
		Residential	Allotments	Commercial	

APPENDIX F: GENERIC REMEDIATION STATEMENTS

GENERIC REMEDIATION OPERATIONS FOR THE PURPOSE OF CONSTRUCTION WORKS

General Measures

Prior to the commencement of any works the Contractor, in agreement with the Engineer, shall:

- Prepare a detailed Method Statement outlining how the objectives of this Remedial Strategy will be achieved.
- Inform the Engineer of any risk, identified and assessed, which could impact upon the Engineer's activities.
- Prepare the necessary COSHH statements and Health & Safety Plan in accordance with CDM regulations.
- Inform the engineer of the progress of the site works to ensure that the engineer is present during the remedial works.

The Contractor shall satisfy the Health & Safety Executive with regard to all matters concerning the health, safety and welfare of persons on the site.

The Contractor shall ensure that:

- Personnel, plant, materials and other equipment related to the contract are confined within the boundaries of the site.
- Prior to commencement of the works appropriate fencing and warning signs will be installed to delineate the works.
- Any live services lying within the site boundary are marked and protected, or appropriate arrangements made to truncate them.
- Good practices relating to personal hygiene are adopted.
- Site plant shall be operated and site operations shall be carried out in such a manner to minimise nuisance and to limit, as far as practicable, noise emissions from the site. Noise emissions shall, as a minimum, be in accordance with local authority requirements or planning conditions.
- Suitable precautions are implemented at all times to prevent off-site migration of pollutants via airborne dust.
- Sweeping and cleaning of the site entrance and public highway(s) is to be carried out where necessary, depending on weather and site conditions, and as required by the Local Authority.
- Suitable precautions are taken to prevent the spread of mud and debris on public highways.
- Refuelling of mobile plant is undertaken in a designated area. Above ground oil storage tanks shall comply with the requirements of Pollution Prevention Guideline PPG2. A spill kit shall be kept on site, adjacent to the designated refuelling area.

This Implementation Plan is based on the proposed development, the ground investigation and subsequent risk assessment detailed in the Phase II report and is in accordance with the HSE Protection of Workers and the general public during the development of contaminated land**.**

Dilapidation Survey

A dilapidation survey of site boundaries, adjacent properties and highways, via dated photographs or video footage should be undertaken prior to the commencement of works.

Security and Fencing

Prior to commencement of the works the site boundaries and working areas should be delineated and appropriate fencing and warning signs should be installed.

Services

A full services search and liaison with all relevant utility companies regarding work in close proximity to their apparatus should be undertaken prior to any works.

Wheel Wash

Sweeping and cleaning of the site entrance and public highway(s) is to be carried out where necessary, depending on weather and site conditions, and as required by the Local Authority.

Dust and Odour Control

Dust generation during the development of the site will arise as a result of excavation, stockpiling, loading and haulage and is not expected to be problematic except during periods of extended dry weather. Dust control by water spray shall be implemented as necessary. Odour control measures must be implemented during excavation works. Boundary monitoring shall also be carried out during the development works.

Noise and Nuisance

Site plant shall be operated and site operations shall be carried out in such a manner to minimise nuisance and to limit, as far as practicable, noise emissions from the site. Noise emissions shall, as a minimum, be in accordance with local authority requirements or planning conditions.

Pollution Control

During the works appropriate surface run-off and groundwater control measures are to be implemented (e.g. surface water cut-off ditches to collect run-off from contaminated areas, temporary bunding etc.) to prevent pollution of ground and surface waters being caused.

Surface run-off should be discharged, via an interceptor, to the foul sewer. The Contractor shall be responsible for obtaining the necessary discharge consents.

Importation of Materials

It is the Contractors responsibility to assess any materials proposed for importation to the site and to ensure that they meet the criteria set out in this report. This may include laboratory testing or the review of investigation data and laboratory testing carried out by others. Any laboratory testing shall clearly demonstrate that the soils tested are uncontaminated and suitable for use in the appropriate areas.

The topsoil should be a suitable growing medium, and within the textural characteristics for classification as topsoil, in accordance with BS 3882 (2015) – Specifications for Topsoil.

Any material brought onto site should be free of detritus and deleterious materials (such as timber, glass and asbestos); will not have a noticeable odour and will not be sourced from areas where Japanese Knotweed or other invasive or injurious plants, as specified by the Environment Agency, are suspected to have been growing.

This data will be supplemented by field and laboratory testing undertaken by the Engineer during the remediation works. All test data obtained will be collated by the Engineer for inclusion in the Completion Report.

The rate of analysis is dependant on the source of the material, which is as follows:

- Virgin quarried material – 1 analysis per 200 tonnes of imported material (approximately 1 analysis per 125m^3 assuming a density of 1.6g/cm^3)
- Material that can be demonstrated to be from a virgin source (greenfield land) - 1 analysis per 100 tonnes (approximately 1 analysis per 62.5m^3 assuming a density of 1.6g/cm^3) with a minimum 3 analysis per source
- Material from other sources – and 1 analysis per 50 tonnes (approximately 1 analysis per 31m^3 assuming a density of 1.6g/cm^3 with a minimum 3 analysis per source

Test data will be initially compared to the Demeter Environmental Tier 1 GAC's, which are presented in Appendix G. If the Soil Organic Matter is greater than 1%, SSAC's will be derived if required. Samples will be analysed to a broad range suite including arsenic, asbestos screen, beryllium, cadmium, chromium (III and VI), copper, cyanide, lead, mercury, molybdenum, nickel, PAH's (USEPA 16) selenium, sulphur, thallium, hydrocarbons (TPHCWG), vanadium, zinc. Additional analysis may be undertaken dependant on the source of the material.

Any imported material for use in garden and landscaped areas will comply with BS 3882:1994 Classification 4(b) General Purpose Grade or better. The material shall be free of aggressive weeds, fragments of glass, bricks, concrete, wire or other potentially hazardous foreign matter and bulk vegetative growth. All material shall also comply with the contaminant concentration requirements.

Duty of Care certificates will be required for material(s) imported onto the site. The source of the material must be detailed on the certification. This certification should be provided and confirmed as acceptable prior to the importation of materials.

Assessment Criteria for Imported Materials

Generic assessment criteria for imported materials are based on the GAC's presented in Appendix F and is dependant on the use of the material on the site, which are given hereunder:

- Material brought onto site to raise/restore site levels or for fertility purposes – the GAC will be used as the threshold criteria
- Material brought onto site as part of a cover system (i.e. protecting end users from impacted soil below the cover system) – 90% of the GAC will be used as the threshold criteria
- Material brought onto site as part of a cover system which includes a geotextile (i.e. protecting end users from impacted soil below the cover system) –the GAC will be used as the threshold criteria

Where there are exceedances, SSAC's will be derived using sample specific Soil Organic Matter (SOM) and the same procedure as above will be used to derive sample specific assessment criteria

Validation of Depth of Cover

There are a number of options to verify the depth of cover on garden and landscaped areas, namely:

Options for Validation of Depth of Cover

Option	Description	Method of Validation
1	Validation on completion of the laying of the cover system	Sufficient hand held trial pits will be excavated to obtain samples of the cover material for chemical analysis will be undertaken at positions determined on the day of the excavations (to prevent preferential laying). The number of trial pits will be based on the area of the garden and landscaped areas, as well as the depth of cover and the density of the soil (assumed to be 1.6g/cm^3). One trial pit will be taken for each sample form each source (minimum of three trial pits). The trial pits will be taken to the geotextile layer at the base of the cover to determine the depth of cover.
2	Validation of the cover system during the laying of the cover	Prior to works a temporary bench mark will be set up adjacent to the closest area of hard standing, and spot levels of the are subject to the cover system will be taken. Stakes will be placed in the ground at the positions the levels were taken from. On completion of any excavations further spot levels will be taken to determine the reduction in site levels, and on completion of the laying of the cover system further spot levels will be taken to determine the depth of cover.

General Earthworks

The following earthworks operations may be undertaken on site:

- Site clearance to remove trees, bushes, turf and vegetation
- Topsoil strip and transport to stockpile for potential future re use on site (reuse onsite subject to its suitability)
- Localised lime stabilisation of soft soils to improve strength
- Undertake general cut and fill balance to facilitate construction levels
- Control of site drainage during earthworks

All earthworks required for development works are to be undertaken in accordance with the Contract Documentation and Specification for Highway Works; this includes the re-use of all site won materials and use of all imported materials.

All suitable excavation arisings generated by site re profiling and remediation works shall be re-used on site as fill on site.

All imported materials will be assessed and validated in accordance with the earthworks specification.

- The following materials will be re used on site:
- Natural clay and sand from cut areas of site

The following site won materials will be disposed offsite to landfill:

- Vegetation
- Metals, wood and other materials unsuitable for re use on site
- Surplus arising of materials for off site disposal to landfill shall be characterised and chemically tested for Waste Acceptance Criteria (WAC) prior to disposing off site to landfill

It is anticipated that imported materials will be required as follows:

- General bulk fill
- Construction materials for floor slabs and drainage
- Clean fill materials for service trenches
- Clean inert topsoil and subsoil cover in landscaped areas

Where clean cover is imported, it is not acceptable to import materials from sources of known contaminative land use. Chemical analysis shall be undertaken to assess the suitability of imported materials prior to acceptance on site.

The Contractor will keep an accurate record of the materials excavated and removed from the site as part of the remediation works, including details of where the material is disposed of. The information will be supplied to the Engineer and will form part of the Completion Report.

The material to be used as topsoil for the proposed garden areas will be imported to the site and should comprise of inert soils that satisfy the requirements of this land use.

Stockpiling

Where earthworks stockpiles are required, these stockpiles shall be located on areas of the site which have been prepared so as to minimise cross contamination of both the stockpiled and the underlying materials, and to prevent contaminated leachates from entering the existing surface water system. This may be achieved by the use of impermeable liners, trenches and bunds where necessary.

Crushing

Localised areas of hard standing at the surface, buried concrete slabs and other buried artificial hard materials may be crushed on site for reuse as suitable fill. All metal, plastic and putrescible materials are to be separated and disposed off site for recycling or disposal to landfill.

Programme of Works

A development programme is detailed separately within the appointed contractors Development Programme.

General Responsibilities for the Engineer (Supervision and Verification)

The Engineer will ensure that the requirements of this Implementation Plan are complied with in a safe and orderly manner.

The responsibilities of the Engineer shall include, but not be limited to, the following:

- Overseeing the remedial and ground preparatory works.
- Liaison with the appointed groundwork contractor and general monitoring of the works
- Verification of the successful implementation of the proposed remedial measures
- Retrieval of soil and water samples and the subsequent scheduling of appropriate laboratory analysis to enable verification of various aspects of the works, and to advise the Project Manager of progress.
- Liaison with statutory authorities as required.

The Engineer will maintain records of the works to include the following:

- Aspects relating to non-compliance with either this Implementation Plan.
- Locations of sampling, analysis and verification of depth of cover identified on as built drawings
- Site surveys as necessary to record the locations of excavation and filling activity.
- Test results.
- Records of laying on water mains
- Records of installation of gas protection measures
- Records of imported materials
- Records of material taken off site

On satisfactory completion of all the works the Engineer will prepare a Verification Report. Copies of the Verification Report will be issued to the client, the agent the Local Authority and if applicable, the NHBC.

The Completion Report will stand as certification that the remedial and ground preparatory works have been carried out in accordance with this Implementation Plan.

The Completion Report may include:

- A summary of the preparatory & remedial works undertaken, including any works associated with unforeseen ground conditions.
- Verification test results associated with any "hot-spot" treatment, including plans showing sample locations & levels, and the extent of any "hot-spot" excavations.
- Details of the fate of any arisings excavated from any "hot-spot".
- Verification test results associated with proposed source materials for clean cover
- Copies of any correspondence with Regulators relating to specific aspects of the remedial works.
- Documented evidence demonstrating the placement of the proposed cover system
- Documented evidence demonstrating the installation of the proposed gas protection measures
- Documented evidence demonstrating the laying of the water mains
- The use of the appropriate concrete specification

The above recommendations will take account of the actual remedial works undertaken, and may differ significantly from recommendations originally presented in the site investigation report.

General Works

The following remedial works are advised:

- General site clearance of surface materials and vegetation.
- Stripping of topsoil and stockpiling for subsequent re-use in garden and landscape areas subject to confirmation of suitability by contamination analyses.
- Break-up of slabs and hardstanding.
- Removal of below ground obstructions.
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc.) for reuse on the site or removal from site.
- Re-profiling of ground levels to achieve the desired development levels.
- Placement of a sufficient cover on garden and landscaped areas.

Any trees currently under a tree preservation order (TPO) shall be identified and agreed with relevant authorities prior to the commencement of the works. All trees subject to a TPO shall be clearly identified and protected by chestnut paling with fluorescent tape.

The site shall then be cleared of all residual debris, any vegetation, shrubs, bushes and unprotected trees as instructed by the Client.

Removal of Below Ground Obstructions

All foundations associated with the former buildings and other relict structures will be chased out and grubbed-up, in order to remove potential obstructions to new foundations and infrastructure.

Where relict structures are found to retain fluid contaminants, works shall cease and the Local Authority contacted in order to approve an appropriate methodology for decommissioning.

Deep excavations for the removal of structures etc. will be unstable in the short term and continuous side support will be necessary.

Where significantly deep foundations (e.g. piles) cannot be removed by conventional means, they are to be cut at a depth to be agreed with the Engineer and the position of the remaining lower section is to be accurately recorded by survey.

Suitable materials derived from grubbing-up shall be stored in a location on site, to be agreed with the Engineer, prior to crushing. Any unsuitable materials shall be removed to a suitably licensed landfill site.

Watching Brief

The groundworkers should maintain vigilance during demolition, excavation and other earthworks for any indications of contamination, including the following:

- Olfactory evidence of contamination, e.g. fuel, solvent or other odours from the ground or excavated spoil
- Visual evidence of contamination such as staining or unusual colourings
- Presence of free product (e.g. fuel) in soils or groundwater
- Presence of asbestos containing materials

Should any visual or olfactory evidence of contamination be observed on the site, the Engineer should be contacted immediately to determine a course of action.

Contingency for Unknowns

Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the remedial works.

- If unanticipated ground is encountered during the remedial works, the Contractor should immediately seek further advice from the Engineer. Any works in the area of unanticipated ground should cease and the Local Authority must be contacted.

Should an area of contamination be identified by visual or olfactory means the following procedure will be followed:

- Immediately stop all works in the area where contamination is suspected;
- Immediately inform the Site Project Manager who should then contact the engineer;
- The engineer will judge each occurrence on merit and should it be deemed necessary and will attend Site to oversee the removal of the 'hotspot' and collect validation samples;
- Any excavated material should be isolated from all other material at the Site and be disposed of to a suitably licensed facility. The engineer should be supplied with consignment notes for all off-Site disposal;
- The excavation should remain open until the validation has been completed; and
- Any identified hot spot would need to be appropriately classified prior to disposal to landfill (or transferred to a treatment centre). If material is identified as hazardous then the Site needs to be registered with the Environment Agency as a producer of hazardous waste. This can be done online and requires the company's registration code and a code that relates to the industry type.

Any unanticipated grossly contaminated soil\fill should be placed in temporary stockpiles on hardstand or visqueen, suitably covered and bunded.

Analysis of an appropriate number of samples, for an appropriate range of determinants, should be undertaken. On receipt of the results, the Engineer will liaise with the Contractor regarding the most appropriate remedial option.

Excavation of Contaminated Soil\Fill

If encountered during the earthworks, any impacted soils should be excavated and stockpiled prior to subsequent treatment and/or removal from site. The Engineer will inspect and sample from the resultant excavations. A minimum of 5 verification samples shall be taken from the excavation sidewalls and base.

In larger excavations, additional verification samples shall be taken from the exposed excavation surfaces on a 10m grid.

Grossly contaminated soil\fill shall be placed in temporary stockpiles on hardstand or polythene sheeting and be suitably covered to minimise the potential for dust\odour nuisance, and prevent surface water run-off. A copy of the suggested protocol for the removal of grossly contaminated soil/fill is presented in Appendix B.

Given the proximity of properties, and in order to avoid any potential odour nuisance, stockpiles of material should be exported from site as soon as practically possible.

Excavations should not be left open for longer than is necessary, and should be securely cordoned-off using 2m high Herras-type fencing, with appropriate warning signs whenever excavation works are suspended.

Export to Landfill

Any material exported from site to landfill should be hauled by a registered waste carrier in accordance with the requirements of the Duty of Care Regulations, 1991 and the Landfill (England & Wales) Regulations 2002.

A transfer note should be completed, signed and retained by the parties involved. The transfer note should include the volume of waste, the nature of the material and a statement of its chemical composition, details of the source and destination sites, and details of the haulier.

In order to protect the general public from dust, wagons that are to be used for the haulage of the contaminated material from the site must be sheeted. In addition, the Contractor must ensure that no fluids seep from the wagons.

In order to provide the landfill facility with information regarding chemical composition of the waste, analysis of any material that requires removal from site will be undertaken.

It is advised that WAC analyses will be undertaken at a rate of 1 analyses per 500m3 of material to be removed off site.

Backfill of Excavations

Excavations (to remove relict structures, contamination etc) should be backfilled as necessary to achieve the desired levels, with suitable materials and subjected to sufficient compaction.

Boundary Issues

The Client's Designer should ensure that proposed levels tie in with the surrounding infrastructure, and ground levels of adjacent properties (after allowance for the placement of any required soil cover).

Advice should be sought from the Engineer if mobile contamination is encountered close to the site's boundaries.

Monitoring & Grouting of Boreholes

Monitoring wells shall be decommissioned prior to the destruction of their associated headworks. This work shall be undertaken in accordance with Environment Agency guidance in "Decommissioning of Redundant Boreholes & Wells".

Health And Safety Of Construction Workers

The works should be undertaken in accordance with the CDM Regulation 2007. The remediation contractor will have duties of Designer and Contractor under these regulations.

Exposure of site personnel and the general public to potential hazards on site will be controlled and kept to a minimum at all times. Only authorised persons will be allowed to access the site.

The Contractor will ensure appropriate health & safety measures for all site personnel during site works. The Contractor will also carry out a health and safety risk assessment with appropriate precautionary measures planned and recorded in advance by adequately trained and qualified persons. Adequate procedures to deal with emergency situations relating to dangers arising on site will be put in place. During all works, the principles outlined in the Protection of Workers and the General Public during Development of Contaminated Land (HSE, 1991) will be adhered to.

Responsibility for health and safety on site will be in the hands of the Site Safety Officer.

As with any brownfield development there is the potential for further previously unidentified hotspots of contamination to be present at the Site. As such, it is recommended that the contractor provides appropriate inductions to all groundworkers who are required to perform sub-surface work at the Site in order to ensure they are made aware of the possibility of encountering contamination at the Site. In addition, good standards of personal hygiene should be observed and appropriate levels of personal protective equipment (PPE) and respiratory protective equipment (RPE), where applicable, provided and utilised in order to mitigate the potential for direct contact.

Contractor will ensure that:

- All site personnel are informed of the significance of land affected by contamination and the associated risks to human health on site prior to commencing work. Instructions regarding the health and safety measures required will be issued to all site personnel. All persons shall then sign a declaration to state their agreement to comply with the requirements of their brief. Refusal to sign the declaration or non-compliance with any of the agreed measures shall result in barred entry to the site.

- Suitable personal protective equipment (PPE), which shall include clothing, footwear, gloves and respiratory equipment (if required) shall be provided for all site personnel who shall be advised on the use of PPE items on the site with the items remaining on site at all times. Records of the adequate condition of the PPE shall be kept and any faulty or ineffective PPE shall be replaced promptly.

- Appropriate measures shall be taken to ensure that any contaminated material is not transferred between the 'contaminated' and 'clean' areas on site. All equipment utilised within the contaminated area shall be thoroughly cleaned before it is used outside the contaminated area.

- All workers shall not eat, drink or smoke in the vicinity of any contaminated material. Comprehensive welfare facilities shall be provided for all site staff, to enable workers to wash prior to leaving the site. First Aid facilities shall be provided on site with adequately trained first-aiders, trained in relation to site-specific hazards, being available on site during working hours.

- Health and Safety risks to site workers and adjacent site users relating to dust, noise, odour and vibration shall be appropriately addressed prior to commencement of site works.

Waste Regulations

The development of this site will require localised reprofiling to accommodate the approved development elevation. The reprofiling works will require the excavation and handling of made ground materials, potentially historically contaminated materials (associated with the former land use) and natural soils. These may be handled / treated by the following manner;

Where made ground materials are contaminated to the extent that they represent a risk to the proposed development and wider environment, these materials will be subject to in-situ or ex-situ treatment or removed and disposed of off site.

Where excavated made ground materials are not considered to represent a risk to the proposed development or wider environment the materials will be retained on site for use within the engineering of the site levels.

The made ground materials could classify as wastes as such, their excavation and handling could be subject to Waste Management licensing. Consultation should be made with the Environment Agency to confirm whether the proposed works are:

- Subject to Waste Management Regulations
- Subject to Waste, Code of Practice (COP)
- Should be registered as exempt from Waste Management licensing or require a mobile licence
- Require a Waste Management License

Reporting

On completion of the works a Completion Report will be prepared and submitted to the local authority in order to satisfy them that the works have been completed successfully and allow any appropriate planning conditions to be discharged. If applicable the completion report will also be submitted to the NHBC for approval in accordance with NHBC Handbook Chapter 4.1.

This report will include the following:

- A description of all works undertaken.
- An accurate record of any excavations.
- Photographs evidence of excavations and the depth of cover
- The results of all chemical testing and contamination assessments.
- Records of the laying of the water mains
- Records of concrete specification
- Waste transfer notes and records of delivery of imported materials
- Confirmation that the works have been completed in accordance with this Implementation Plan.

On completion of the works a Completion Report will be prepared and submitted to the local authority in order to satisfy them that the works have been completed successfully and allow any appropriate planning conditions to be discharged. If applicable.

A programme of works has not yet been developed by the contractor, however a mutually agreeable call off procedure will be agreed between the developer and the consultant to ensure timely validation of plots.

Assessment of Suitability of Cover System

There are a number of possible scenarios with regards to the depth of cover and suitability of the cover material, the procedures for each scenario are presented hereunder:

Table 1: Potential Scenarios With Regards to Depth of Cover

SCENARIO	DEPTH OF COVER SUFFICIENT	COVER MATERIAL SUITABLE FOR USE	FURTHER WORKS
1	Yes	Yes	No further works are required
2	Yes	No	1) Sample specific assessment criteria will be derived as given above (Assessment Criteria for Imported Materials) 2) Where there are exceedances, the subject sample will be subject to retesting (3 retests) to ensure that the original result represent the cover material. The average of the four results will be used to determine the suitability of the soil. 3) Where exceedances are still present after retesting, a DQRA will be undertaken to determine if the material is suitable to be left on site. 4) Where the sample represents more than 1 plot, samples of the previously unsampled plots will be taken and analysed to determine if the soil in these plots are suitable for use, and the same procedure is followed 5) If the material is determined to be unsuitable, the material represented by the sample will be removed.
3	No	Yes	Samples of the material underlying the cover material will be taken and analysed to the contaminants of concern it the conceptual model. To determine, on a plot by plot bases if the depth of cover is suitable.
4	No	No	1) Samples of the material underlying the cover material will be taken and analysed to the contaminants of concern it the conceptual model. To determine, on a plot by plot bases if the depth of cover is suitable. 2) Sample specific assessment criteria will be derived as given above (Assessment Criteria for Imported Materials) 3) Where there are exceedances the subject sample will be subject to retesting (3 retests) to ensure that the original result represent the cover material. The average of the four results will be used to determine the suitability of the soil. 4) Where exceedances are still present after retesting, a DQRA will be undertaken to determine if the material is suitable to be left on site. 5) Where the sample represents more than 1 plot, samples of the previously unsampled plots will be taken and analysed to determine if the soil in these plots are suitable for use, and the same procedure is followed 6) If the material is determined to be unsuitable, the material represented by the sample will be removed.

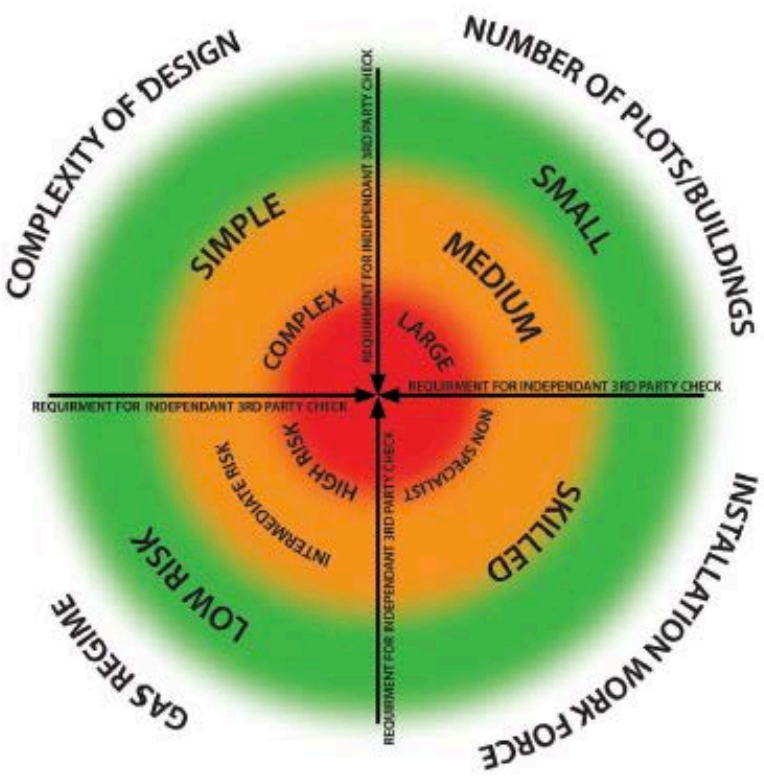
Validation on Installation of Gas Protection Measures

The verification of the gas protection measures will be undertaken in line with BS8485:2015 and CIRIA C735 'Good Practice on the Testing and Verification of Protection Systems for Buildings Against Hazardous Ground Gases'.

The verification of the gas protection measures will be undertaken by an independent party in order to avoid conflicts of interest.

The level of verification required is dependant on four factors, namely`;

1. Gas regime for the site;
2. Size of the development;
3. Complexity (design and installation) of gas protection measures;
4. Qualifications and experience of workforce.



Example of elements to be considered

Gas regime

Low risk	CS2
Intermediate risk	CS3/4
High risk	CS4 and above

Design complexity

Simple	Few service entries/penetrations, gas membrane and sub floor void
Complex	Variety of gas protection measures, numerous columns/ penetrations/service entries, corners and small spaces

Number of plots/buildings

Small	<5
Medium	3–15
Large	>10

Installation workforce

Non specialist	General builder/groundworker
Skilled	Qualified and experienced installer (NVQ Level 2 qualification in gas protection installation).

Figure 3.1 ***Illustration of factors to be taken into account in determining the scope and level of independence in the verification of gas protection systems in buildings***

Examples of Details of Verification and Integrity Testing are provided below

Example Levels of Verification and Testing for Non-Reinforced Slabs		
Gas Regime / Risk	**Installer Experience**	**Suggested Levels of Verification and Integrity Testing**
Low risk CS2 with venting(*) Basic radon protection measures	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including photographs to independent verifier.
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min one visit). Installer to supply sign off sheets (verification evidence) including photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 with venting(*) Full radon protection area	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations etc. independently air lanced to ASTM D4437. Contractor to supply sign off sheets (verification evidence) including photographs to verifier. Consideration given to need for/scope of integrity testing (e.g. initially on say 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min two visits). 25 per cent all joints, pipe penetrations etc independently air lanced to ASTM D 4437. Remaining 75 per cent joints, pipe penetrations etc tested to recognised standard by installer (as detailed in method statement/CQA plan). Installer to supply sign off sheets (verification evidence) to verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).
High risk VOCs etc, CS3 (no venting) or CS4 and above with venting(*)	Qualified[1] and experienced installer (50 per cent of operatives to hold qualification)	Verifier (consultant[4] or third party qualified and experienced installer1) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations independently air lanced to ASTM D 4437. Installer to supply sign off sheets (verification evidence) to verifier for all pours. Consideration given to need for scope of integrity testing (eg initially on 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).

Example Levels of Verification and Testing for Reinforced All Slabs		
Gas Regime / Risk	**Installer Experience**	**Suggested Levels of Verification and Integrity Testing**
Low risk CS2 with venting(*) Basic radon protection measures	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including sub grade acceptance forms and photographs to independent verifier.
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 25 per cent concrete pours (min two visits), including vented void, subgrade etc. Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 with venting(*) Full radon protection area	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours including vented void, subgrade etc. All joints, pipe penetrations etc independently air lanced to ASTM D4437. Consideration given to the need for and scope of integrity testing (eg initially on say 50 to 25 per cent of pours then falling to 25 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections.
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to 50 per cent of concrete pours, including vented void, subgrade etc 25 per cent of joints, pipe penetrations etc independently air lanced to ASTM D4437. Remaining joints, pipe penetrations, corners etc tested to a recognised standard by installer (as detailed in method statement and CQA plan). Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs etc to independent verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results and no concerns raised by visual inspections).
High risk VOCs etc, CS3 (no venting) or CS4 and above with venting(*)	Qualified[1] and experienced installer (50 per cent of operatives to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct a thorough verification (visual) inspection prior to all concrete pours including vented void, subgrade etc. All joints, pipe penetrations etc independently air lanced to ASTM D4437. 100 per cent leak detection considered on VOC/ hydrocarbon contaminated sites.. Consideration given to need for/scope of integrity testing (eg initially on 50 to 25 per cent of pours then falling to 25 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).

Example Levels of Verification and Testing for All Slabs With a Minimum of 150mm Ventilated Sub Floor Void (Gas regime defined by characteristic situation as set out by Wilson et al (2007), and all other recent good practice guidance and British)		
Gas Regime / Risk	**Installer Experience**	**Suggested Levels of Verification and Integrity Testing**
Low Risk (Amber 1)	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 10 plots (minimum 5). Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections[3].
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections[3].
Intermediate Risk (Amber 2)	General builder/ groundworker/ landfill operative (no relevant qualification[1])	Verifier (consultant[4] or qualified and experienced installer[1]) to to conduct thorough verification (visual) inspection of first 10 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at approx. frequency of 1 in 20 plots Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections).
	Qualified[1] and experienced installer (minimum one operative to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of the first 5 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at a frequency of about 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/ scope of integrity testing (eg initially on 10 to 25 per cent of plots then falling to 0 5 per cent of plots if acceptable results obtained and no concerns raised by visual inspections)[3].
High Risk (red) VOC's and hydrocarbons	Qualified[1] and experienced installer (all operatives to hold qualification)	Verifier (consultant[4] or qualified and experienced installer[1]) to conduct thorough verification (visual) inspection of all plots, and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections)[3].

*) Assumes venting designed to keep steady state concentration of CH4 below one per cent in void, sites designed with higher levels of gasin the void should adjust the frequency of inspection and testing as appropriate;

1) Relevant qualification is NVQ Level 2 in gas protection installation;

2) Before the works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced;

3) Consideration should be given to carrying out integrity testing/leak detection (ie smoke, tracer gas or dielectric testing) on the above basis and/or if an unacceptable amount of damage/loss of integrity is found during visual inspections. In this instance the consultant should discuss with the relevant personnel, strategies to prevent this recurring. This could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc. ;

4) Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan;

5) Air lancing is the only integrity test that has an independently recognised international standard suitable for testing taped and welded seams and should be used at the frequency suggested in the table;

6) Where a sufficiently robust protection layer (protection fleece, protection boards or insulation) are laid directly on the membrane, inspection after placement of the reinforcement should not be necessary;

7) Air lancing is the only integrity test that has an independently recognised international standard suitable for testing taped and welded seams and should be used at the frequency suggested in the table;

Reporting of Verification of Gas Protection Measures

The Liverpool City Council Gas Protection Validation Proforma will be used for the reporting of the verification of the gas protection measures.

APPENDIX G: DRAWINGS

Demeter Environmental Ltd
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Brighton Office:
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136-140 Old Shoreham Road
Brighton, East Sussex
BN3 7BD
Tel: 01273 741 727

Email: enquiries@demeter-environmental.co.uk

Drawing 1

LA New Hey Road (Site A)

Scale: NTS

Site Location Plan

Demeter Environmental Ltd
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Drawing 2

LA New Hey Road (Site A)

Aerial Plate

Date Taken: 26th March 2012

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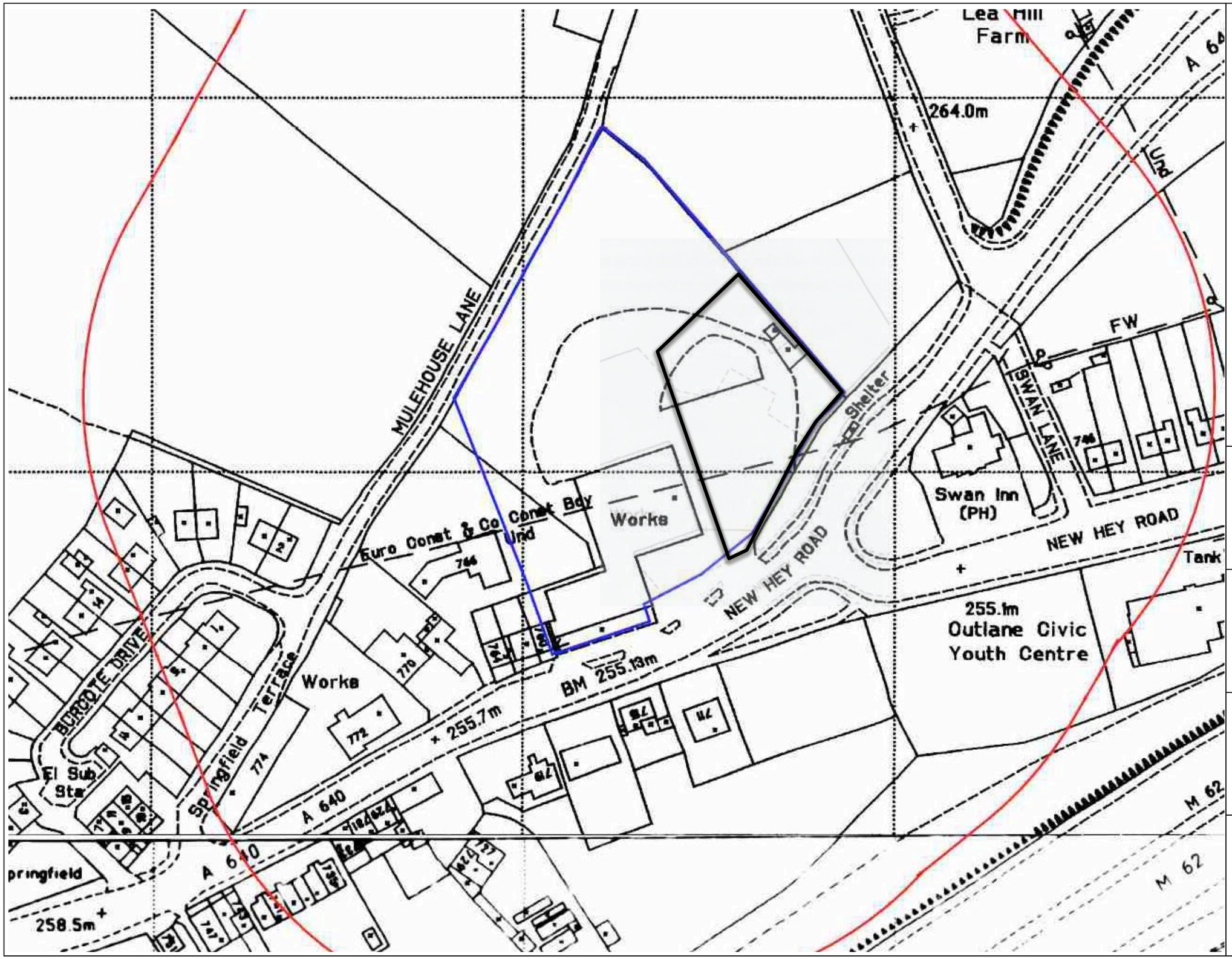
Drawing 2

LA New Hey Road (Site A)

Aerial Plate

Date Taken: 26th March 2012



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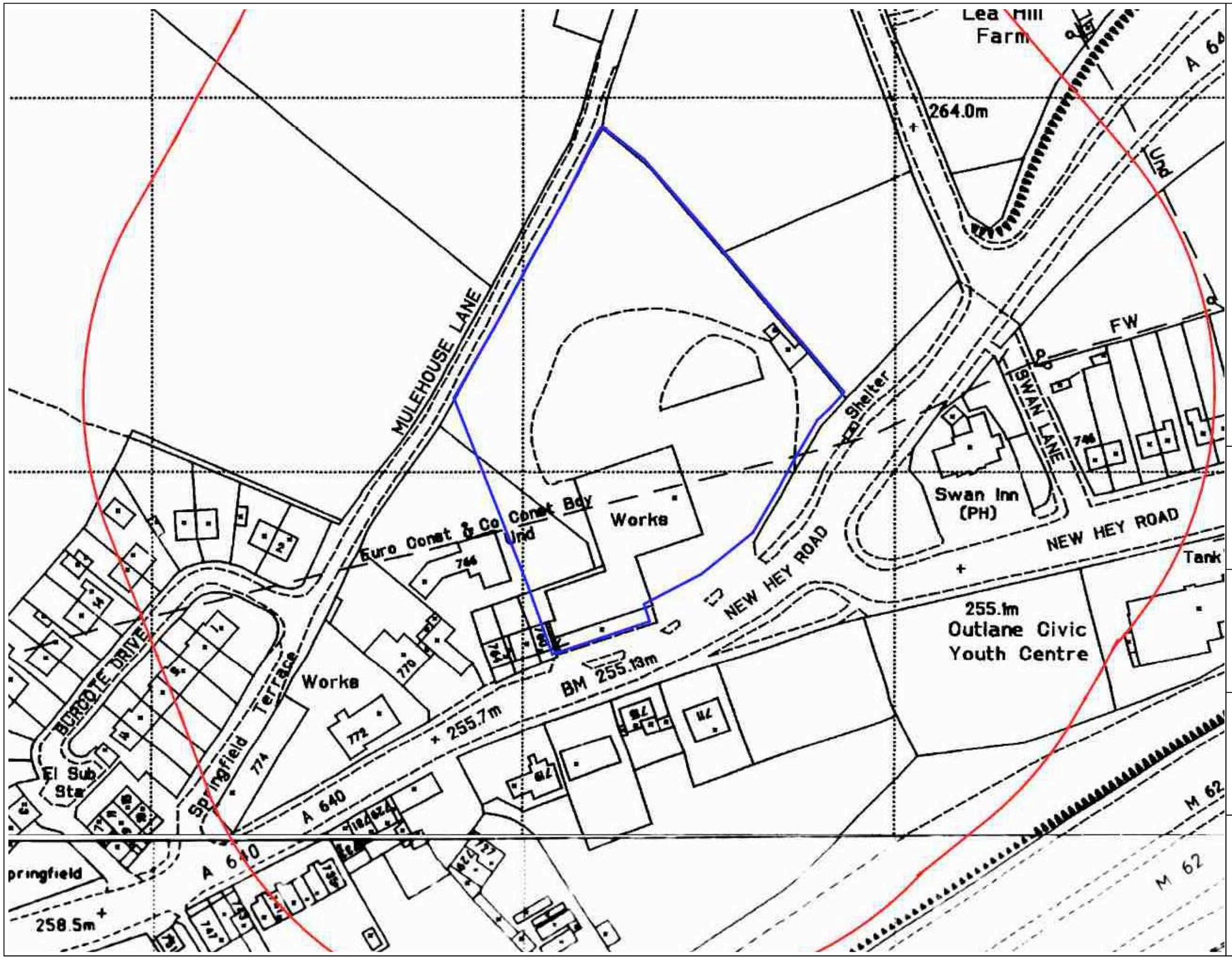
Drawing 3

LA New Hey Road (Site A)

Scale: 1:1,000 at A3

Site Layout



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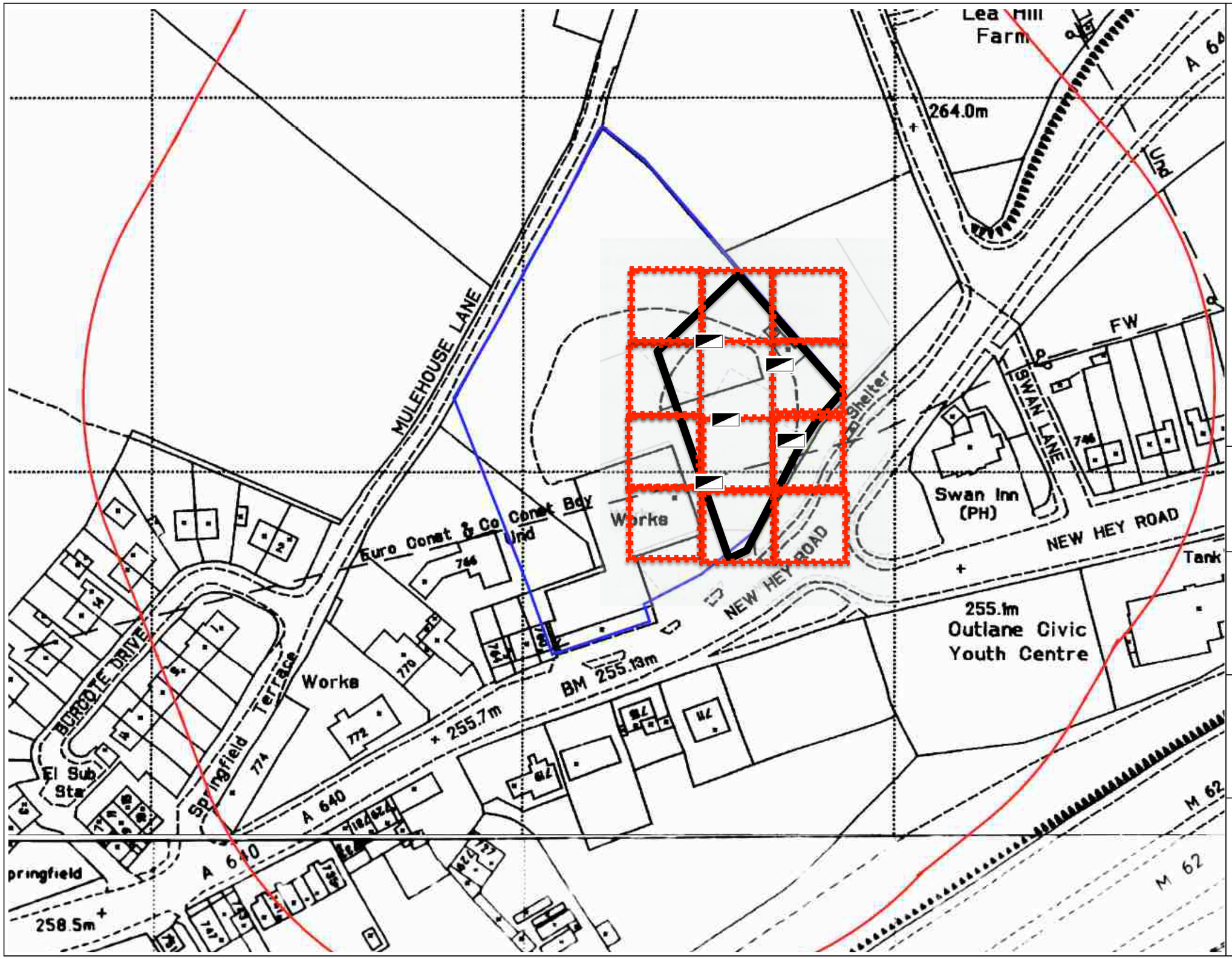
Drawing 3

LA New Hey Road (Site A)

Scale: 1:1,000 at A3

Site Layout



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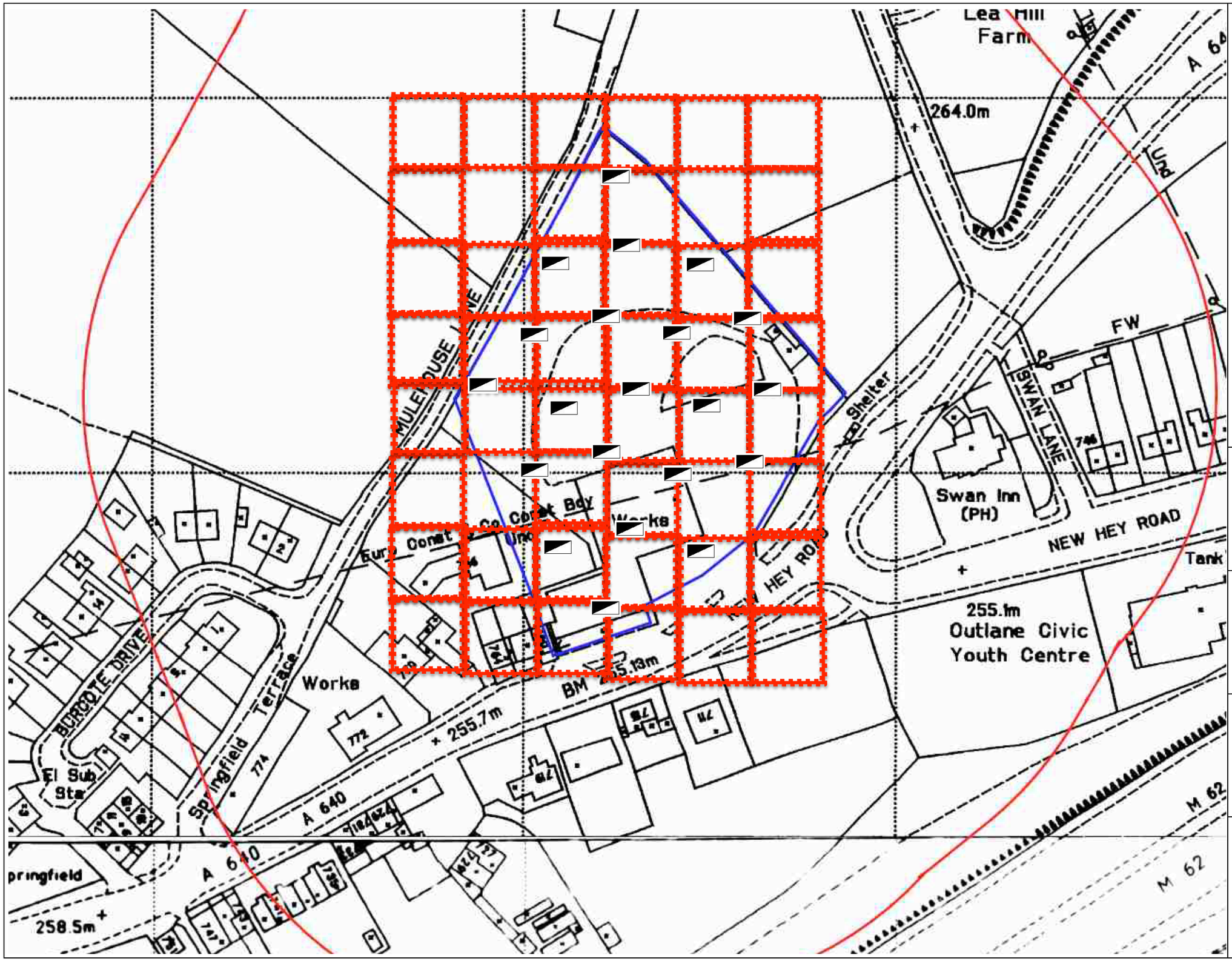
Drawing 4

LA New Hey Road (Site A)

Scale: 1:1,000 at A3

Proposed Site Investigation Layout



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Drawing 4

LA New Hey Road

Scale: 1:1,000 at A3

Proposed Site Investigation Layout