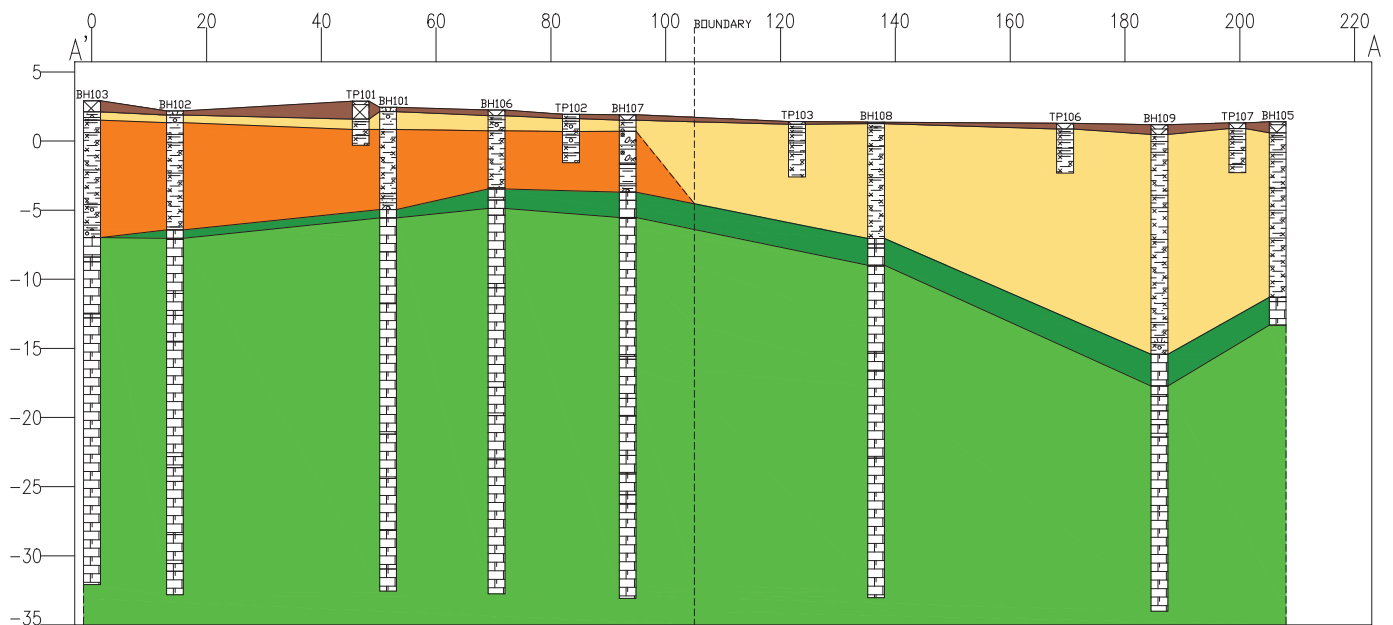




DO NOT SCALE



- | | | | |
|----------------------|----------------------|----------------------------|-----------|
| MADE GROUND/TOPSOIL | TOPSOIL | CLAYEY SANDY GRAVEL | LIMESTONE |
| SUPERFICIAL DEPOSITS | SILTY SANDY CLAY | SANDY GRAVELLY CLAY | |
| LAMBETH CLAY | SILTY SAND | SILTY CLAY | |
| STRUCTURELESS CHALK | CHALK | SANDY GRAVELLY COBBLY CLAY | |
| CHALK | GRANULAR MADE GROUND | SILTY SANDY GRAVELLY CLAY | |

A	NOT ISSUED	XXX	ISSUED FOR		
REV	DATE	BY	DESCRIPTION	CHK	APD
CAD FILE:			DESIGN-DRAWN:	DATE:	
5-1			TCS	January 2016	
DRAWING STATUS:					
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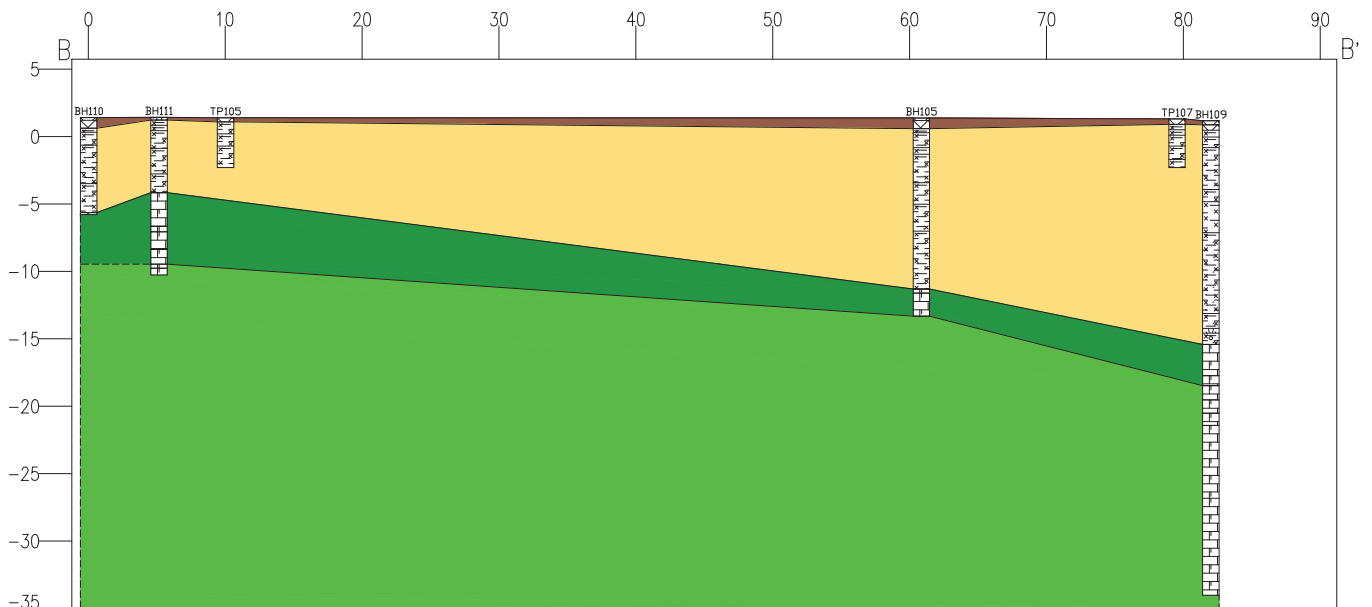
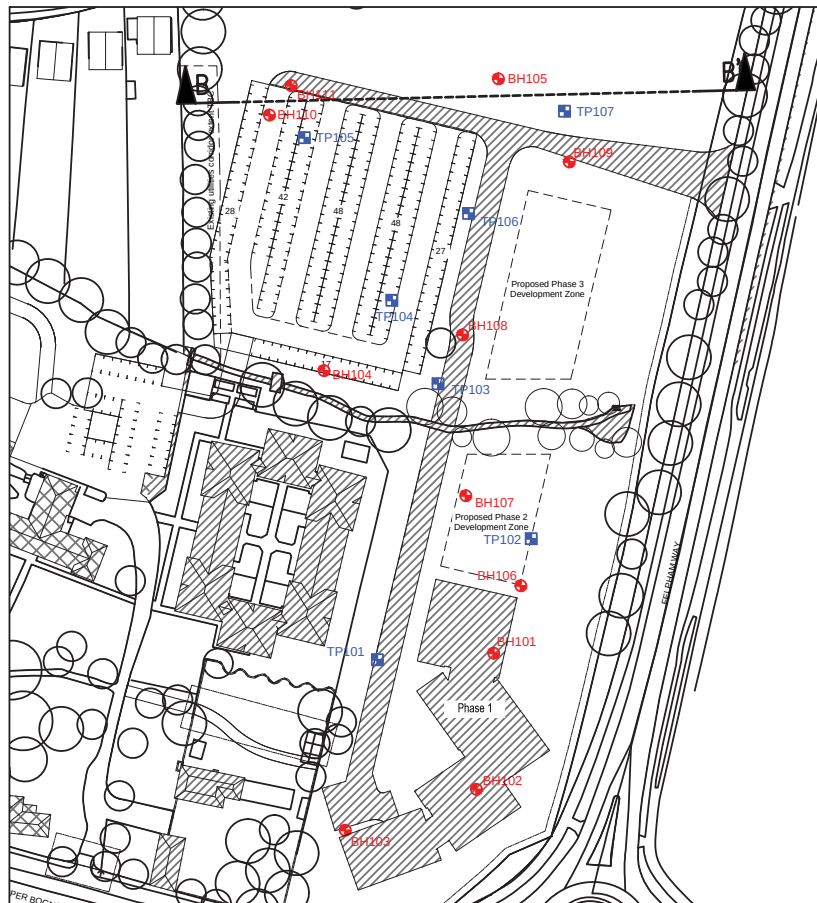
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PROJECT:			UNIVERSITY OF CHICHESTER EDT PARK BOGNOR REGIS		
TITLE:			CROSS SECTION A-A'		
SCALE @ A3:		CHECKED:	APPROVED:		
NTS		JH	PC		
PROJECT No:		DRAWING No:		REV:	
70010938		5-1		A	



DO NOT SCALE



MADE GROUND/TOPSOIL
SUPERFICIAL DEPOSITS
STRUCTURELESS CHALK
CHALK

GRANULAR MADE GROUND
SILTY CLAY
CLAY/SILT
SILTY SANDY GRAVELLY CLAY
SILTY SANDY CLAY
CHALK
PEAT
TOPSOIL



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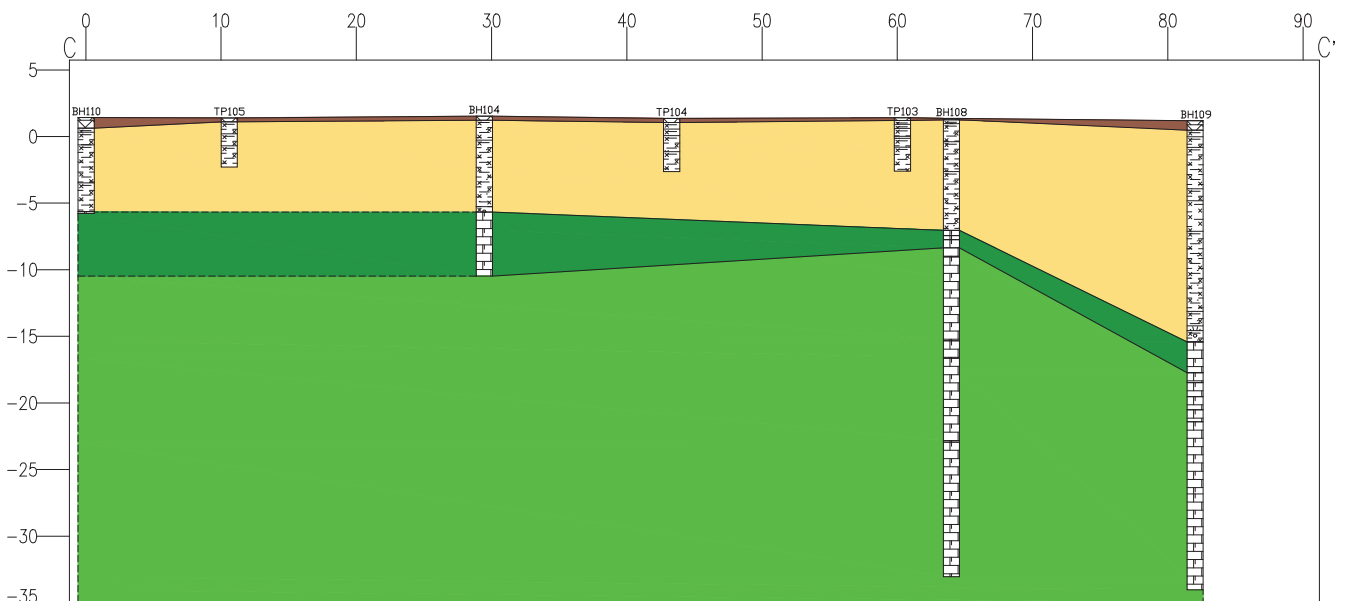
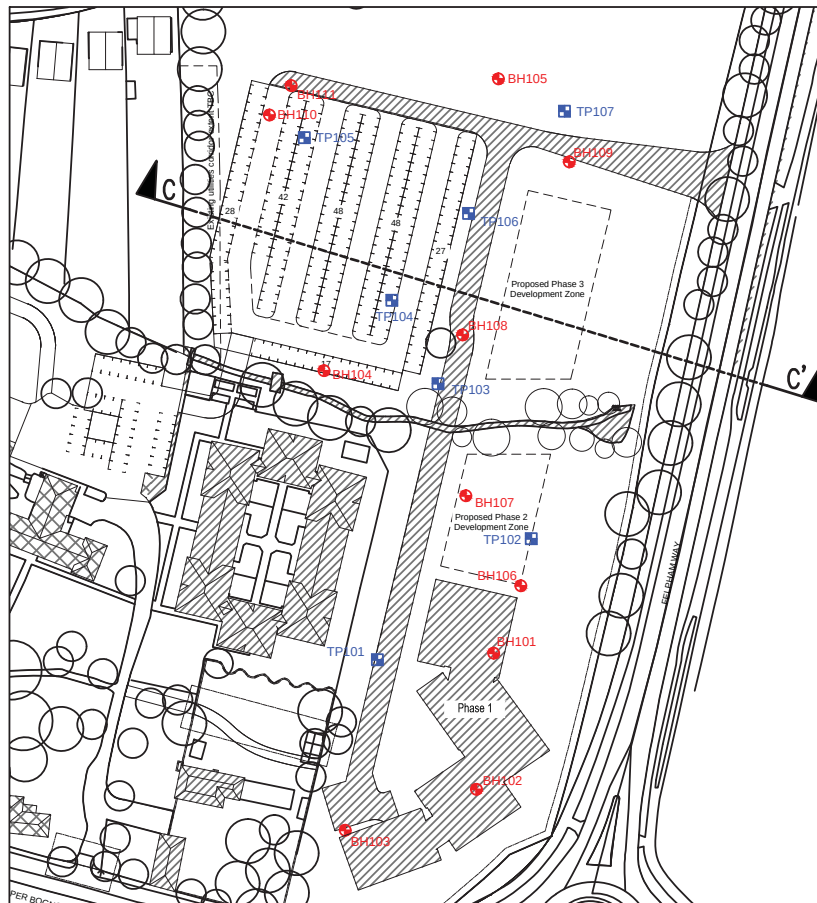
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TITLE: CROSS SECTION B-B'		
SCALE @ A3: NTS	CHECKED: JH	APPROVED: PC
PROJECT No: 70010938	DRAWING No: 5-2	REV: A

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M:\SOIL & GROUNDWATER\PROJECTS\Geotech\70013264 - UoC Bognor Regis Park\5) Project Data\Ground Model\Ground cross sections\Cross section B-B'.dwg



DO NOT SCALE



MADE GROUND/TOPSOIL
SUPERFICIAL DEPOSITS
STRUCTURELESS CHALK
CHALK

GRANULAR MADE GROUND
SANDY GRAVELLY SILT
SILTY GRAVELLY CLAY
CLAY/SILT
SILTY SANDY GRAVELLY CLAY

SILTY SANDY CLAY
CHALK
SILTY CLAY
PEAT

A	NOT ISSUED	XXX	ISSUED FOR	©	©
REV	DATE	BY	DESCRIPTION	CHK	APD
CAD FILE:			DESIGN-DRAWN:	DATE:	
5-3			TCS	January 2016	
DRAWING STATUS:					
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PROJECT:			UNIVERSITY OF CHICHESTER EDT PARK BOGNOR REGIS		
TITLE:			CROSS SECTION C-C'		
SCALE @ A3:		CHECKED:	APPROVED:		
NTS		JH	PC		
PROJECT No:		DRAWING No:	REV:		
70010938		5-3	A		



Legend

Holes with SUPERFICIAL DEPOSITS - Depth of strata top Contours

metres

	0.1 to 0.26
	0.26 to 0.35
	0.35 to 0.45
	0.45 to 0.57
	0.57 to 0.79



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00.005.01 0.02 0.03 0.04
Kilometres

Esri, HERE, DeLorme, MapmyIndia, © OpenStreet



TITLE:

University of Chichester - ETDP

FIGURE No:

FIGURE 4

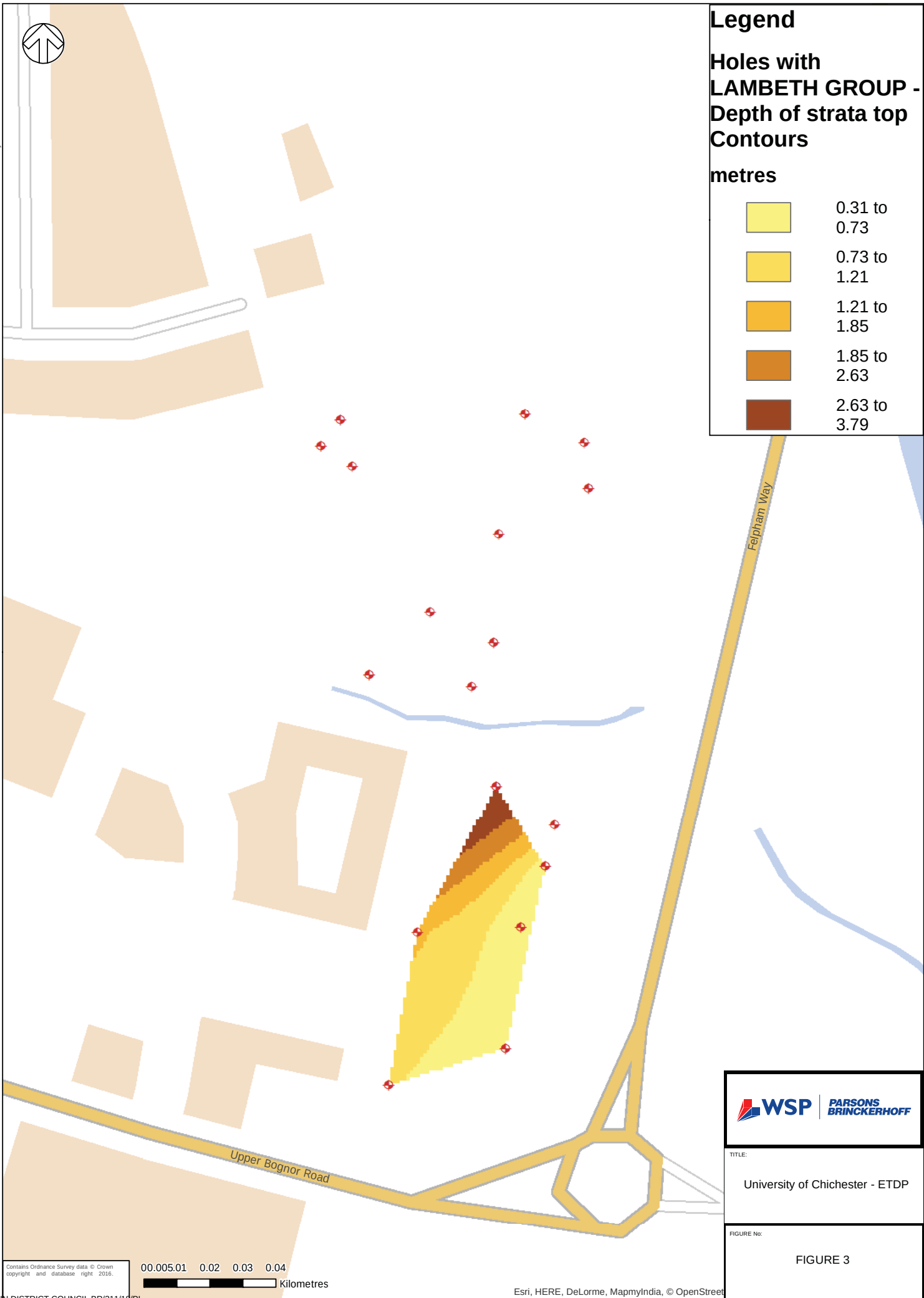


Legend

Holes with LAMBETH GROUP - Depth of strata top Contours

metres

	0.31 to 0.73
	0.73 to 1.21
	1.21 to 1.85
	1.85 to 2.63
	2.63 to 3.79





Legend

Holes with WHITE CHALK SUBGROUP - Depth of strata top Contours

metres

	5.62 to 7.55
	7.55 to 8.97
	8.97 to 10.69
	10.69 to 12.83
	12.83 to 16.56



TITLE:

University of Chichester - ETDP

FIGURE No:

FIGURE 5

Appendix G

HUMAN HEALTH RISK ASSESSMENT

DERIVATION OF GENERIC QUANTITATIVE ASSESSMENT CRITERIA FOR HUMAN HEALTH

APPROACH

In order to undertake a GQRA, contaminant concentrations are compared to appropriate generic assessment criteria. Current UK industry practice is to use, as first preference, UK Soil Guideline Values (SGV) which are generic assessment criteria (GAC) published by the Environment Agency and derived using the Contaminated Land Exposure Assessment model (CLEA).

The CLEA model provides an approach for the assessment of chronic risks to human health from concentrations of a substance within soil.

The current version of the model (v1.06) was published in September 2009 and, following its publication, a number of SGVs were also produced. The SGVs published to date are limited to a small number of substances. Consequently, where published SGV do not exist, other GACs can be used. These include:

- GACs derived in accordance with the CLEA v1.06 model by authoritative bodies such as Chartered Institute of Environmental Health (CIEH) and Environment Industries Commission (EIC).
- In-house GAC derived in accordance with the CLEA v1.06 model and associated documents by suitably qualified and experienced consultants.

The approach adopted by WSP has been to generate GACs for chronic risks to human health in-house using CLEA v1.06. In generating GAC WSP has followed the approach presented in the following publications:

- Environment Agency (2009a) Human Health Toxicological Assessment of Contaminants in Soil Report SC050021/SR2. January 2009.
- Environment Agency (2009c) Updated Technical Background to the CLEA Model Report SC050021/SR3 January 2009.
- Environment Agency (2009b) CLEA Software (Version 1.04) Handbook (and Software). Report SC050021/SR4, January 2009.

NOTE ON C4SLS

In April 2014, screening levels representative of 'low risk' whilst still being 'strongly precautionary' were published by CL:AIRE for six substances (arsenic, benzene, cadmium, hexavalent chromium, lead and benzo(a)pyrene as a surrogate marker for polyaromatic hydrocarbons). These are known as Category 4 Screening Levels (C4SLS) and have been endorsed for use by Defra.

With the exception of lead (see Chemical Specific Assumptions), WSP's current approach to the assessment of risks to human health is to continue to evaluate minimal risk through the use of SGV and in-house derived GACs, and to use the published C4SLS as a secondary tier of assessment, until such time as additional suitable C4SLS are published and/or in-house values are derived.

INPUT PARAMETERS

TOXICOLOGICAL DATA

Toxicological data for respective contaminants have been selected following Environment Agency guidance. Where UK guidance is available (i.e. existing published toxicological (TOX) reports) respective Health Criteria Values (HCV) have been adopted. Where no UK TOX reports are available the following references have been used (given in order of preference):

- Published UK toxicity reviews to derive HCV within Nathanial et. al, 2009 and EIC/CL:AIRE 2009;
- Other appropriate UK sources;
- Authoritative European sources;
- International Organisations (e.g. World Health Organisation); or
- Appropriate, authoritative US sources (e.g. USEPA).

FATE AND TRANSPORT DATA

Fate and transport characteristics for the contaminants for which GAC have been derived using the following hierarchy of data sources:

- Environment Agency (2008a), Compilation of Data for Priority Organic Pollutants, Report SC050021/SR7, November 2008.
- Defra/Environment Agency sources (e.g. Environment Agency, Review of the Fate and Transport of Selected Contaminants in the Soil Environment, Draft Technical Report P5- 079/TR1 (Environment Agency 2003a)).
- Published fate and transport reviews to derive HCV within Nathanial et. al, 2009 and EIC/CL:AIRE 2009.
- Other UK Government documents.
- European data sources.
- International data sources; (e.g. World Health Organisation).
- Other international sources (e.g. USEPA).

Where appropriate and where sufficient data is available, values have been adjusted to reflect a UK soil temperature of 10°C (e.g. Kaw).

LAND USE AND EXPOSURE SCENARIOS

Our default soil type under a GQRA has been established as a Sandy Loam with a default pH of 7 and with Soil Organic Matters of 1%, 3% and 6%.

In generating GAC, the default CLEA assumptions have been applied to a range of likely human health exposure scenarios and associated critical age receptor groups including:

- Residential with Homegrown Produce Consumption
- Residential without Homegrown Produce Consumption
- Allotments
- Commercial/Industrial

In addition, WSP has derived exposure scenarios for the following commonly encountered land uses:

- Parks
- Open Spaces

Note: These do not currently reflect those exposure scenarios set out in the C4SL report and will be updated in the near future.

OPEN SPACES LAND USE

Prior to the publication of the C4SL report, the CLEA model did not explicitly consider an Open Spaces land use. In many cases a residential end use was applied as a conservative proxy which can often lead to unnecessary remediation due to unrepresentative exposure pathways and characteristics which are not representative of an Open Spaces land use, for example indoor air inhalation of contaminant vapours.

The Open Spaces land use scenario developed by WSP is considered to be appropriate for areas generally larger than local parks which are visited less frequently and are typically a distance from residential areas (e.g. a nature reserve).

WSP has developed a set of Generic Assessment Criteria for Open Spaces end use through the development of a Conceptual Site Model for Open Space which considers the relevant exposure pathways and receptor characteristics. These criteria are considered suitably sensitive to apply to a wide range of Open Space areas. The Conceptual Site Model adopted is as follows:

- The soil ingestion and dermal exposure pathways are active;
- The inhalation of outdoor dusts and vapours pathways are active;
- The soil is a typical sandy loam type;
- The critical receptor is a female child between the ages of 0-6 years (i.e. based on a standard residential receptor) who visits the site on three occasions a fortnight and spends 3 hours on the site on each visit (the exception being during the first year of life when exposure frequency is set at 50% of the number of visits and duration); and
- Fifty per cent of the time spent on site is involved in moderate intensity activity and fifty per cent in passive activity.

A detailed breakdown of the chosen modelling characteristics can be provided on request.

It should be noted that Open Spaces criteria are not considered appropriate for use for a School Playing Fields scenario where formal and regular sports take place or for a Parks land use where visits will tend to be far more frequent.

PARKS LAND USE

As with the Open Spaces land use, prior to the publication of the C4SL report, the CLEA model did not explicitly consider a Parks land use and unnecessary remediation may have occurred due to the inappropriate use of a Residential land use scenario as an overly conservative proxy.

The Parks land use scenario developed by WSP is considered to be appropriate for local parks and open areas typically located adjacent to residential housing and more frequently used than in an Open Spaces scenario.

WSP has developed a set of Generic Assessment Criteria for Parks end use through the development of a Conceptual Site Model for Parks which considers the relevant exposure pathways and receptor

characteristics. These criteria are considered suitably sensitive to apply to a wide range of Open Space areas. The Conceptual Site Model adopted is as follows:

- The soil ingestion and dermal exposure pathways are active;
- The inhalation of outdoor dusts and vapours pathways are active;
- The soil is a typical sandy loam type;
- The critical receptor is a female child between the ages of 0-6 years (i.e. based on a standard residential receptor) who visits the site on five days a week and typically spends 1.5 hours on the site on each visit with two weeks holiday a year; and
- Two-thirds of the time spent on site is involved in moderate intensity activity and one-third in passive activity.

A detailed breakdown of the chosen modelling characteristics can be provided on request. It should be noted that Parks criteria are not considered appropriate for use for a School Playing Fields scenario where formal and regular sports take place.

CHEMICAL SPECIFIC ASSUMPTIONS

ORGANIC SUBSTANCES

GAC for organic substances have not been limited to their theoretical soil saturation although the theoretical soil saturation limit is provided and can be considered by our risk assessors in their assessment. Petroleum hydrocarbon fractions are, where appropriate, addressed based on Hazard Index and so are additionally not limited to soil saturation within their assessment.

CYANIDES

The primary risk to human receptors from free cyanide in soils is an acute risk (i.e. a single dose could have a lethal affect as opposed to adverse effects from cumulative intake (chronic affect)).

There is no current UK guidance available for calculating acute risks from free cyanide, therefore an in-house methodology has been used to derive an acute GAC of 60 mg/kg for all exposure scenarios. The value is given for Free or Easily Liberatable Cyanide.

LEAD

The SGV for lead was withdrawn by the EA in 2009, and in 2011 it withdrew its published TOX report in light of new scientific evidence. The C4SL for lead has been derived using the latest scientific evidence from a large human dataset. As such, no chemical-specific margin was applied in the derivation of the C4SL for lead. It may be possible for WSP to derive a GAC for lead using the same dataset and applying a chemical-specific margin, but the value is likely to be lower than UK natural background concentrations. Therefore, WSP has adopted the C4SL as its primary generic screening value for lead until such time as an alternative GAC is published by an authoritative body.

INHALATION OF GROUNDWATER-DERIVED VAPOURS

The CLEA model does not explicitly consider the potential for chronic impact to human health from indoor inhalation of concentrations of volatile vapours from dissolved phase contamination. The potential exists for this to be an important exposure route for a limited number of highly volatile contaminants. GAC have been calculated for volatile contaminants for volatilisation from groundwater using an in-house implementation of the Johnson and Ettinger model (WSP In-house Groundwater Model V1.1). The WSP model is based upon the Johnson and Ettinger model described in the CLEA guidance and has been adapted to account for a dissolved phase source through consideration of (a) partitioning from groundwater to soil vapour, and (b) transport through the capillary zone.

The WSP spreadsheet implementation also includes checks to ensure that values generated do not exceed the pure phase solubility of a substance within water.

The target concentration in air is set based upon the Inhalation TDI or ID determined for the substance either from published Environment Agency or other sources.

TDI or ID values are usually presented in units of $\mu\text{g/kgbw-1 day-1}$ in which case the values are converted into μgm^{-3} based on an adult inhaling 20m^3 per day and weighing 70kg (Table 3.3 SR2 (EA 2009a)). Where appropriate the TDI is adjusted to take account of the MDI.

In the absence of UK guidelines, our exposure scenario conservatively considers a groundwater source 1.0m below the base of any building i.e. a very shallow aquifer, corresponding with the depth of a soil source as adopted in the generic scenario in the CLEA model. Our default soil type under a GQRA is a Sandy Loam with the characteristics detailed below.

Parameters Used in the Derivation of WSP GAC for Inhalation of Groundwater Derived Vapours

Parameter	Definition (Units)	Value	Source
θ_a	air filled soil porosity ($\text{cm}^3\text{cm}^{-3}$)	0.2	Environment Agency (2009c), Table 4.4 (Sandy Loam)
θ_w	water filled soil porosity($\text{cm}^3\text{cm}^{-3}$)	0.33	Environment Agency (2009c), Table 4.4 (Sandy Loam)
θ_T	total air and water filled soil porosity($\text{cm}^3\text{cm}^{-3}$)	0.53	Environment Agency (2009c), Table 4.4 (Sandy Loam)
θ_r	Residual soil water content cm^3/cm^3	0.12	Environment Agency (2009c), Table 4.4 (Sandy Loam)
θ_s	Saturated soil water content cm^3/cm^3	0.387	USEPA (2004), User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, Table 4 (Sandy Loam)
α_1	Point of inflection in the water retention curve where $d\theta_{wc} / dh$ is maximal, cm^{-1}	0.0689	Environment Agency (2009c), Table 4.4 (Sandy Loam)
N	van Genuchten curve shape parameter, dimensionless	1.4708	Calculated from Equation 4.1 Environment Agency (2009c), Table 4.4 (Sandy Loam)
M	van Genuchten curve shape parameter, dimensionless	0.3201	Environment Agency (2009c), Table 4.4 (Sandy Loam)
R	Mean inter-particle pore radius (cm)	0.006	USEPA (2004), User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, Table 4 (Sandy Loam)

Building specific parameters have been considered for all of the generic building types as defined in the CLEA (2009a) report:

Building Parameters

	Units	Small Terraced	Justification (based on Environment Agency 2009c)	Office (pre 1970)	Justification (based on Environment Agency 2009c)
A_B	cm^2	280000	Table 4.21 (No basement)	4240000	Table 4.21 (No basement)
L_T	cm	115	Assumes source is 1 m below the building	115	Assumes source is 1m below the building

	Units	Small Terraced	Justification (based on Environment Agency 2009c)	Office (pre 1970)	Justification (based on Environment Agency 2009c)
Q_s	$\text{cm}^3 \text{s}^{-1}$	25	Section 10.3, p131	150	Section 10.3, p131
L_{crack}	cm	15	Table 4.21	15	Table 4.21
A_{crack}	cm^2	423.3	Table 4.21	1647.3	Table 4.21
H	m	4.8	Table 4.21	9.6	Table 4.21
A_{foot}	m^2	28	Table 4.21	424	Table 4.21
Ex	hr^{-1}	0.5	Table 4.21	1	Table 4.21

The required contaminant specific inputs for each contaminant have been obtained from published Environment Agency sources as detailed in the table below or obtained from a literature review as described in SR7 (EA 2008).

Contaminant Specific Parameter Sources

Parameter	Units	Source/Justification
D_{air}	$\text{m}^2 \text{s}^{-1}$	Environment Agency (2008), Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values, Ref. SC050021/SR7
D_{water}	$\text{m}^2 \text{s}^{-1}$	Environment Agency (2008), Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values, Ref. SC050021/SR7
K_{aw}	unitless	Environment Agency (2008), Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values, Ref. SC050021/SR7
S	$\mu\text{g/l}$	Environment Agency (2008), Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values, Ref. SC050021/SR7

NON-AQUEOUS PHASE LIQUIDS

For many contaminants, no risk is calculated at concentrations below the pure phase solubility of the contaminant. Caution is applied when Non-Aqueous Phase Liquids (NAPL) are likely to be present, either where these have been detected during monitoring or where the concentration of a component in a mixture exceeds 10% of its calculated effective solubility. In such cases a separate assessment of the generation of volatile vapours from NAPL via modelling or a soil vapour survey may be required.

STATISTICAL ASSESSMENT

Where considered appropriate, the analytical data can be subject to statistical analysis using the techniques published by CL:AIRE and the Chartered Institute of Environmental Health (CIEH) in the guidance document 'Guidance on Comparing Soil Contamination Data with Critical Concentrations' (CL:AIRE 2008) as part of the package of improved UK guidance highlighted in DEFRA discussion paper 'Assessing risks from contamination – a proportionate approach. Soil Guidance Values: the Way Forward (CLAN 06/2006)'.

In identifying realistic hazards to human health exposure areas are first identified as the area across which a critical receptor is likely to be active. The application of individual or average concentrations within an exposure area, derived from a limited number of samples, may not be representative of actual risk. Consequently, to be representative of uncertainty and risk, an appropriate Confidence

Limit of the mean for each exposure area should be applied within the assessment of risk in the context of assessment for planning purposes. However, this approach is only appropriate where non-targeted sampling has been undertaken and sufficient samples have been collected from the same population.

Planning investigations assume that the mean concentration of a contaminant in soil at the site significantly exceeds the assessment criteria until proven otherwise.

Based on the CIEH guidance, under Part 2A the key question will usually be “can we confidently say that the level of contamination on the site is high relative to the appropriate measure of risk”. Therefore, in Part 2A contaminated land investigations, assume that the mean concentration of a contaminant in soil at the site does not significantly exceed the assessment criteria until proven otherwise.

Under Part 2A therefore the tests applied are required to determine if the 95th Lower Confidence Limit of the true population mean falls above the applied screening criteria. If it is identified that the 95th Lower Confidence Limit of the true mean concentration does not fall above the applied screening criteria then a further test can be applied to determine if the true mean concentration falls below the applied screening criteria on the balance of probabilities. The CIEH guidance emphasizes that “In all cases, the significance tests should be applied only if the regulator is satisfied that all sampling and testing has been carried out according to good technical practice and that the data are representative of the land under scrutiny at an appropriate scale.

In a planning context, analysis of the data is undertaken using ProUCL to determine the type of distribution and most appropriate test to calculate a 95% Upper Confidence Limit (UCL95). Once the data has been analysed ProUCL is used to determine whether the highest value represents an outlier, and, if so this outlier is removed and the statistical tests are re-run to determine the type of distribution and most appropriate test to calculate a UCL95. Once a satisfactory UCL95 has been determined this is compared to the applied GAC to determine the potential significance of the recorded concentrations.

SELECTED REFERENCES

The following key references have been considered (this list is not exhaustive):

CL:AIRE (2014) Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, Final Project Report (Revision 2), SP1010, 24 September 2014.

CL:AIRE / CIEH (2008) Guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008.

CL:AIRE / EIC (2009) The Soil Generic Assessment Criteria for Human Health, December 2009.

Environment Agency & Defra (2002) R&D Publication CLR8 Priority Contaminants for the Assessment of Land.

Environment Agency (2003) Review of fate & transport of selected contaminants in the Environment, Report P5-079-TR1.

Environment Agency (2004) Model Procedures for the Management of Land Contamination, September 2004, ISBN: 1844322955.

Environment Agency (2008a) Compilation of Data for Priority Organic Pollutants, Report SC050021/SR7, November 2008.

Environment Agency (2009a) Human Health Toxicological Assessment of Contaminants in Soil, Report SC050021/SR2, January 2009.

Environment Agency (2009b) CLEA Software (Version 1.04) Handbook (and Software), Report SC050021/SR4, January 2009.

Environment Agency (2009c) Updated Technical Background to the CLEA Model, Report SC050021/SR3, January 2009.

Environment Agency (2009d) A Review of Body Weight and Height Data Used in the CLEA Model, Report SC050021/Final Technical Review 1, January 2009.

Nathanial et. al., (2009) The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd edition), Land Quality Press, Nottingham, ISBN 0-9547474-7-X.

USEPA (2004) User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings.