



# **West Winch Housing Access Road**

## **Environmental Statement Chapter 12: Appendix 12.3D: GRR Appendices**

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Document Reference: NCC/3.12.03d

Version Number: 01

Date: January 2018



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## **1 Introduction**

- 1.1.1 this document contains the GRR Appendices produced by WSP and some users may not be able to access all technical details. If you require this document in a more accessible format please contact [westwinchhar@norfolk.gov.uk](mailto:westwinchhar@norfolk.gov.uk).

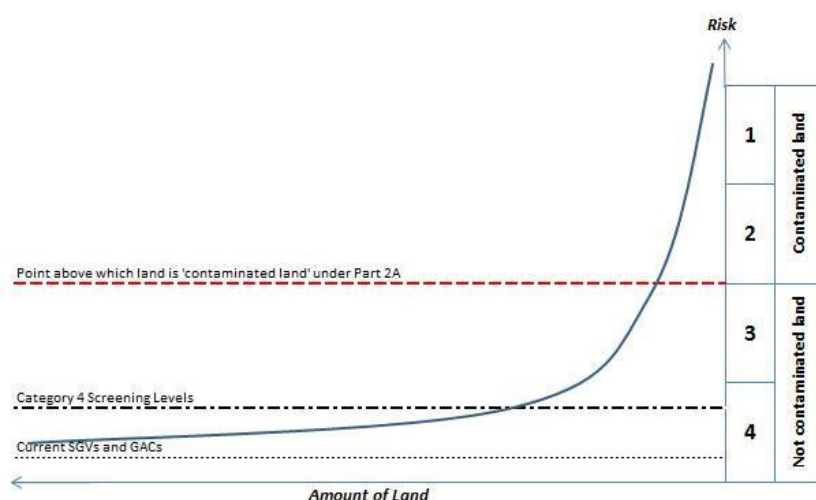
# METHODOLOGY FOR THE DERIVATION OF GENERIC QUANTITATIVE ASSESSMENT CRITERIA TO EVALUATE RISKS TO HUMAN HEALTH FROM SOIL & GROUNDWATER CONTAMINATION

## UK APPROACH

In the UK, the potential risks to human health from contamination in the ground are usually evaluated through a generic quantitative risk assessment (GQRA) approach. This allows generic and conservative exposure assumptions to be readily applied to risk assessments and can be a useful tool for rapidly screening data and to identify those contaminants or scenarios that could benefit from further investigation and/or site-specific detailed quantitative risk assessment (DQRA). Current industry good practice is to use the approach presented in the Environment Agency (EA) publications SR2<sup>1</sup> and SR3<sup>2</sup>. This approach allows the derivation of Generic Assessment Criteria (GACs), primarily for chronic exposure.

In April 2012, the Department of Environment, Food and Rural Affairs (Defra) published updated statutory guidance<sup>3</sup> which introduced a four category approach to determining whether land in England and Wales is contaminated or not on the grounds of significant possibility of significant harm (SPOSH). **Figure 1** presents a graphical representation of the categories.

**Figure 1: Four Categories for Determining if Land Represent a SPOSH**



Cases classified as Category 1 are considered to be SPOSH based on actual evidence or an unacceptably high probability of harm existing. Category 4 cases are those where there is no risk, or a low risk of SPOSH.

<sup>1</sup> Environment Agency 'Human Health Toxicological Assessment of Contaminants in Soil', Report SC050021/SR2. January 2009.

<sup>2</sup> Environment Agency 'Updated Technical Background to the CLEA Model,' Report SC050021/SR3. January 2009.

<sup>3</sup> Defra 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance'. April 2012.

GACs represent a minimal risk level, well within Category 4. A 2014 publication by Contaminated Land: Applications in Real Environments (CL:AIRE), SP1010<sup>4</sup> and endorsed by Defra<sup>5</sup> provided an approach to determine Category 4 Screening Levels (C4SLs) which are higher than the GACs whilst being “more pragmatic but still strongly precautionary”. It also provided C4SLs for six contaminants of concern. Although the C4SLs were designed to support Part 2A assessments to determine ‘contaminated land’ they are specifically mentioned, along with reference to the Part 2A statutory guidance, by the Department for Communities and Local Government (DCLG) for use in a planning context<sup>6</sup>.

An updated version the Contaminated Land Exposure Assessment (CLEA) Workbook (v1.071) was released by the EA in September 2015 to take into account the publication of SP1010. The updates comprised: additional toxicity data for the six chemicals for which C4SLs were derived; two new public open space land use scenarios; updated exposure parameters; options to run the model using C4SL exposure assumptions; and increased functionality. There were no changes to algorithms, so it is still possible to replicate the withdrawn SGVs using the input parameters held within v1.071.

It should be noted that the four category approach has not been adopted in Scotland under Part 2A or the planning regime. The Part 2A statutory guidance applicable in Scotland (Paper SE/2006/44 dated May 2006) does not reflect the changes introduced by Defra in April 2012 which allow for the use of C4SLs within Part 2A risk assessments. Additionally, it is considered that the principal of ‘minimal risk’ should still apply under planning in Scotland, based on current guidance.

## WSP APPROACH

Following the withdrawal of the SGVs, and in the absence of an industry-wide, accepted set of GACs it is down to individual practitioners to derive their own soil assessment criteria. WSP has used the approach provided within SR2, SR3, SP1010, CLEA Workbook v1.071 and SR4<sup>7</sup> to produce a set of minimal risk GACs. The chemical-specific data within two key publications were considered during their production: CL:AIRE 2010<sup>8</sup> and LQM 2015<sup>9</sup>. Both documents provide comprehensive sets of GACs for different contaminants of concern.

The LQM Suitable For Use Levels (S4ULs) have selected exposure parameters somewhere between those of the SR3 land uses and the C4SL exposure scenarios. This approach was rejected by WSP as not representing minimal risk, however, the LQM S4UL document was critically reviewed and the approach and chemical input parameters were utilised where considered to be appropriate.

An industry-led C4SL Working Group is in the process of deriving a larger set of C4SLs in the near future, for approximately 20 contaminants. This will include a critical review of the chemical input data for all selected substances, and may therefore lead to further amendments to the chemical input data used in the WSP in-house screening values. It is considered likely that the contaminant list will

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<sup>4</sup> CL:AIRE ‘Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination’ SP1010, Final Project Report (Revision 2). September 2014.

<sup>5</sup> Defra ‘SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document’. December 2014.

<sup>6</sup> DCLG Planning Practice Guidance ‘Land Affected by Contamination’, particularly Paragraphs 001 and 007. Ref IDs: 33-001-20140306 & 33-007-20140612.

<sup>7</sup> Environment Agency ‘CLEA Software (Version 1.05) Handbook (and Software)’, Report SC050021/SR4. September 2009.

<sup>8</sup> CL:AIRE ‘The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment’. ISBN 978-1-05046-20-1. January 2010.

<sup>9</sup> Nathanail et al ‘The LQM/CIEH S4ULs for Human Health Risk Assessment’, Land Quality Press, ISBN 978-0-9931084-0-2. 2015.

crossover with the current CL:AIRE GACs. As such, this document was not critically reviewed by WSP.

WSP's current approach to the assessment of risks to human health is to continue to evaluate minimal risk through the use of in-house derived GACs, and to use the published C4SLs as a secondary tier of assessment until such time as additional C4SLs are published and/or in-house values are derived.

## EXPOSURE MODELS

### LAND USES

WSP has largely adopted the exposure assumptions of the generic land use scenarios included within SR3, with two additional public open space scenarios included from within SP1010:

- à Residential with homegrown produce consumption;
- à Residential without homegrown produce consumption;
- à Allotments;
- à Commercial;
- à Public open space near residential housing (POS<sub>resi</sub>); and
- à Public park (POS<sub>park</sub>).

Exceptions are described in the following Sections.

### SOIL PROPERTIES

SR3 assumes a sandy loam soil with a pH of 7 and a Soil Organic Matter (SOM) content of 6% for its generic land uses, based on the geographical spread of topsoils in the UK. WSP has adopted these default values. In addition, GACs based on an SOM of 1% and 2.5% have been derived, based on common experience of the nature of Made Ground and lack of topsoil on many brownfield sites.

### RECEPTOR CHARACTERISTICS AND BEHAVIOURS

SP1010 provides some updated exposure parameters for long-term inhalation rates<sup>10</sup> and the consumption rates for homegrown produce<sup>11</sup> compared to those provided in SR3. This data was used to derive WSP's GACs.

The changes in inhalation rates do not apply to the allotment generic land use scenario, as these are based on the breathing rates for short-term exposure of light to moderate intensity activity which were derived from a study that was not updated in USEPA 2011, so the SR3 rates were retained.

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<sup>10</sup> USEPA, National Centre for Environmental Assessment 'Exposure Factors Handbook: 2011 Edition' EPA/600/R-09/052F. September 2011.

<sup>11</sup> National Diet and Nutrition Survey 2008/2009 to 2010/2011.

## CHEMICAL DATA

### PHYSICO-CHEMICAL PARAMETERS

Physico-chemical properties for the contaminants for which GACs have been derived have been obtained following critical review of the following hierarchy of data sources:

1. Environment Agency/Defra SGV reports where available.
2. Environment Agency 'Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values', Report SC050021/SR7, November 2008.
3. Published fate and transport reviews within Nathanail et. al 2015 and CL:AIRE 2010.

Where appropriate, and where sufficient data is available, values were adjusted to reflect a UK soil temperature of 10°C (e.g.  $K_{aw}$ ).

### TOXICOLOGICAL DATA

Toxicological data for the derivation of minimal risk Health Criteria Values (HCV) for each contaminant was selected with due regard to the approach presented in SR2. Where appropriate, the following hierarchy of data sources was used:

1. UK toxicity reviews published by authoritative bodies including:
  - < EA;
  - < Public Health England (PHE);
  - < Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT); and
  - < Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC).
2. Authoritative European sources such as European Food Standards Agency (EFSA)
3. International organisations including:
  - < World Health Organisation (WHO); and
  - < Joint FAO/WHO Expert Committee on Food Additives (JECFA).
4. Authoritative country-specific sources including:
  - < United States Environmental Protection Agency (USEPA);
  - < US Agency for Toxic Substances and Disease Registry (ATSDR);
  - < US Integrated Risk Information System (IRIS); and
  - < Netherlands National Institute for Public Health and the Environment (RIVM).

Factors such as the applicability of the data to human health (e.g. epidemiological vs. animal studies), the quality of the data, the level of uncertainty in the results and the age of the data were also taken into account in the final selection. Details for specific substances are available on request.

## MEAN DAILY INTAKES

Estimations of background exposure for each threshold substance have been updated. In line with the SR2 approach, the exposure from non-threshold substances in the soil does not take into account exposure from other sources, and as such GACs were derived without consideration of the Mean Daily Intake (MDI) for those substances.

The data published by the EA in its series of TOX reports between 2002 and 2009 was evaluated to determine whether the values were considered to remain valid today. Values from these current UK published sources were not amended unless they were considered to be significantly different so that the GACs remained as comparable as possible with the revoked SGVs.

## ORAL MEAN DAILY INTAKES

Oral MDI were generally estimated as the sum of exposure via the ingestion of food and drinking water using the default adult physiological parameters presented in Table 3.3 of SR2.

Data on the exposure of substances from food ingestion was generally obtained from UK Total Diet Studies (TDS) published by the Food Standards Agency (FSA) and its predecessor the Ministry of Agriculture, Fisheries and Food (MAFF) and from studies commissioned by COT. Where no UK-specific data was available, MDI were derived from the European Food Safety Authority (EFSA), Health Canada and US sources. This was a rare occurrence, and in these instances, the data was evaluated to determine its applicability to the UK.

Data on the concentrations of substances in tap water was obtained from a variety of sources. UK data was used where available, with preference given to Drinking Water Inspectorate (DWI) 2014 data from water company tap water testing (LOD, 1<sup>st</sup> and 99<sup>th</sup> percentile data is available). Where the substance was not included in tap water testing, other UK sources of information were considered including:

- à DWI data from water company tap water testing from previous years;
- à COT; and
- à FSA.

Where UK data was not available, a number of other data sources were considered, largely WHO International Programme on Chemical Safety (IPCS) Concise International Chemical Assessment Documents (CICADs) and background documents for the development of Guidelines for Drinking Water Quality, using professional judgement on the relevance of the data to the UK. The final decision on the MDI from drinking water was made using professional judgement on the balance of relevance and probability, taking into account the detection limit where not detected, Koc and solubility, reduction in use of the substance, banned substances, tight controls (e.g. on explosives) and with due consideration to the SR2 instruction that “if no data or information in background exposure are available, background exposure should be assumed to be negligible and the MDI set to zero....”.

Data from other countries was generally not used because it was considered that the hydrogeology of these countries along with industrial practices were unlikely to be reflective of the UK.



## INHALATION MEAN DAILY INTAKES

Inhalation MDIs were based on estimates of average daily exposure by the inhalation pathway and calculated using the default adult physiological parameters presented in Table 3.3 of SR2.

The inhalation MDIs were generally estimated using background exposure data from the UK, derived from Defra's UK-AIR: Air Information Resource<sup>12</sup>, which provides ambient air quality data from a number of sites forming a UK-wide monitoring network. The MDIs for heavy metals were based on rolling annual average metal mass concentration data from Defra's UK Heavy Metals Monitoring Network from the period October 2009 to September 2010<sup>13</sup>.

Information for some substances was obtained from UK sources including Environment Agency TOX reports and data from the UK Expert Panel on Air Quality Standards (EPAQS). Where recent UK data was not available, data was sourced from the International Programme on Chemical Safety (IPCS), the World Health Organisation (WHO), the Agency for Toxic Substances and Diseases Registry (ATSDR), Health Canada, and various other peer-reviewed sources summarised by LQM/CIEH<sup>14</sup>.

For other substances, where no data or information on background exposure was available, background exposure was assumed to be negligible and the MDI set at 0.5\*TDI in accordance with guidance in SR2.

## PLANT UPTAKE

Soil to plant concentration factors are available in CLEA v1.071 for arsenic, cadmium, hexavalent chromium, lead, mercury, nickel and selenium. For all remaining inorganic chemicals, concentration factors were obtained using the PRISM model. Substance-specific correction factors have been selected in accordance with the guidance established within SR3. This is consistent to the approach utilised in the derivation of the LQM S4UL values and the EIC/AGS/CL:AIRE GAC.

Where there is a lack of appropriate data to enable the derivation of specific soil to plant concentrations factors for organic chemicals, plant uptake was modelled within CLEA v1.071 using the generic equations recommended within SR3, as follows:

- à Green Vegetables – Ryan et al. (1988);
- à Root Vegetables – Trapp (2002);
- à Tuber Vegetables – Trapp et al. (2007); and
- à Tree Fruit – Trapp et al. (2003).

There are no suitable models available for modelling uptake for herbaceous fruit or shrub fruit. Exposure is considered negligible.

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<sup>12</sup> Crown 2016 copyright Defra via uk-air.defra.gov.uk, licenced under the Open Government Licence (OGL).

<sup>13</sup> Defra, 2013 Spreadsheet of historic data for multiple years for the Metals network. Available online at: <http://uk-air.defra.gov.uk/data/metals-data>. [Accessed 13/03/2016].

<sup>14</sup> LQM/CIEH, 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment.

## SOIL SATURATION LIMITS

GACs are not limited to their theoretical soil saturation within CLEA, although where either the aqueous or the vapour-based saturation is exceeded, this is highlighted within the Workbook (compared with the lower of the two values). This affects pathways which depend on partitioning calculations so in reality this only affects the vapour pathways and is relevant to organic substances and other substances, such as elemental mercury, that have a significant volatile component. However, the Workbook highlights saturation for direct contact pathways to indicate to the user where further qualitative consideration of free phase contamination at surface may be required.

Where the lower of the two saturation limits is exceeded and the vapour pathway is the only exposure route being considered, the chronic risks to human health are likely to be negligible. Further evaluation could be undertaken using an alternative model suitable for evaluating non-aqueous phase liquids (NAPLs), such as the Johnson & Ettinger (J&E) approach described in USEPA 2003. However, WSP considers that if NAPLs are suspected, given the known limitations and over-simplifications of J&E, soil vapour monitoring is a more accurate way of assessing potential risks.

Where the lower saturation limit is exceeded for the vapour pathway and a number of exposure routes are being considered, then the contribution from the NAPL via vapour inhalation to the overall exposure can be evaluated using the procedure provided in SR4. WSP would evaluate this as part of a DQRA process or through soil vapour monitoring on-site to determine site-specific soil vapour concentrations.

## CHEMICAL SPECIFIC ASSUMPTIONS

### CYANIDES

Cyanide has high acute toxicity, and short term exposure is an important consideration when assessing the risks from soils contaminated with cyanide. The primary risk to human receptors from free cyanide in soils is an acute risk.

There is no current UK guidance available for calculating acute risks from free cyanide. Consequently, GAC for acute exposure were derived using the algorithms presented in MADEP 1992<sup>15</sup> and assuming a one-off ingestion of 10g of soil (this conservative value has been taken as an upper bound estimate for a one-off soil ingestion rate amongst children). Receptor body weights have been selected according to the critical receptor for each exposure scenario. The lowest of the chronic and acute GAC for each land use scenario were adopted by WSP. Brinckerhoff.

### LEAD

The SGV for lead was withdrawn by the EA in 2009, and in 2011 the EA withdrew their published TOX report in light of new scientific evidence. The C4SL for lead was 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 toxicological data used to derive the C4SLs in deriving the GAC for lead until such time as alternative GACs are published by an authoritative body. The relative bioavailability was set at 100% in line with the approach taken for other GACs, whereas the C4SL assumes 60% for soil and 64% for airborne dust. Thus, the WSP GAC are lower than the C4SLs.

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<sup>15</sup> MADEP 'Background Documentation for the Development of an "Available Cyanide" Benchmark Concentration' 1992. [http://www.mass.gov/dep/toxics/cn\\_soil.htm](http://www.mass.gov/dep/toxics/cn_soil.htm)

## POLYCYCLIC AROMATIC HYDROCARBONS

WSP's approach to the assessment of polycyclic aromatic hydrocarbons (PAHs) uses the surrogate marker approach. BaP was used as a surrogate marker for all genotoxic PAHs in line with the Health Protection Agency 2010<sup>16</sup> recommendations and SP1010. This assumes that the PAH profile of the data is similar to that of the coal tars used in the Culp *et al* oral carcinogenicity study from which the toxicity data for BaP was produced. In reality, this profile has been shown by HPA to be applicable on the majority of contaminated sites based on assessment of sites across the country.

The alternative is the Toxic Equivalency Factor (TEF) approach which uses a reference compound and assigns TEFs for other compounds based on estimates of potency. Key uncertainties with this approach include the assumption that all compounds have the same toxic mechanism of action within the body and that no compounds with a greater potency than the reference compound are present. It is considered by the HPA that the TEF approach is likely to under predict the true carcinogenicity of PAHs and therefore favours the surrogate marker approach.

For these reasons, WSP considers that the adoption of BaP as a surrogate marker for genotoxic PAHs as opposed to the TEF approach is reasonable, even in cases where the PAH profile may differ from that of the Culp *et al* study. In addition, WSP has derived a GAC for naphthalene, which is commonly a risk driver due to its high volatility, relative to other PAH compounds, as an indicator compound for threshold PAHs.

## TRIMETHYLBENZENES

The GAC for trimethylbenzenes can be used for the assessment of any individual isomer (1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene or 1,3,5-trimethylbenzene), or a mixture of the three isomers.

## CHEMICAL GROUPS

For a number of chemical groups, the available toxicity data is for combinations of chemicals. Given that the physico-chemical parameters may differ between the chemicals, the GACs for the chemicals within the groups have been calculated and then the lowest GAC selected to represent the entire group. This was the approach taken by the EA for m-, o- and p-xylenes, and has also been adopted by WSP for:

- à 2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol and 2,3,4,6-tetrachlorophenol;
- à 2-, 3- and 4-methylphenol (total cresols);
- à aldrin and dieldrin; and
- à  $\alpha$ - and  $\beta$ -endosulphan.

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<sup>16</sup> HPA Contaminated Land Information Sheet 'Risk Assessment Approaches for Polycyclic Aromatic Hydrocarbons (PAHs) 2010

## EXPOSURE TO VAPOURS

### INHALATION OF MEASURED VAPOURS

WSP has derived a set of soil vapour GACs ( $GAC_{sv}$ ) that allow for the assessment of measured site soil vapour concentrations, using J&E, in order to establish potential risks via indoor inhalation of vapours. This methodology enables a more robust assessment of exposure via the inhalation of soil vapours indoors than using CLEA-derived soil GAC, as it is based upon measured soil vapour concentrations beneath the site. It also allows for the assessment of vapours from all source terms (i.e. groundwater, soil or NAPL). Outdoor inhalation was not included. WSP considers that the indoor inhalation pathway is the significantly dominant risk-driver.

The generic land use scenarios within CLEA (residential and commercial) that were used to derive the soil GAC were used to define the receptor and building characteristics for the soil vapour GAC. Only residential and commercial generic land use scenarios include the indoor inhalation of vapours pathway.

The  $GAC_{sv}$  were derived for three different soil types; sand, sandy loam and clay, reflecting the importance of this parameter within the J&E model. A depth to contamination of 0.85 m below the base of the building foundation was assumed (i.e. 1 m below ground level). This differs from the depth assumed for the soil GAC (0.5 m bgl), but was selected by WSP as a reasonable worst case scenario.

It is acknowledged that the J&E commonly over-predicts indoor vapour concentrations. In particular, it will significantly over-predict vapour concentrations for suspended floor slabs, which many new builds are constructed with, it does not take into account lateral migration and assumes an infinite source of contamination at steady state conditions. In addition, it is common for soil gas/vapour wells to be installed with at least 1 m of plain riser at the surface and this equates to a total depth of 0.85 m below the building foundation plus a 0.15 m thick foundation, and so is more representative of the depth that samples will be taken from.

The TDSIs and IDs for each substance were converted from  $\mu\text{gkg}^{-1}\text{bwday}^{-1}$  to  $\mu\text{gm}^{-3}$  using the standard conversions quoted in Table 3.3 of SR2, thereby replacing the need to model  $C_{air}$  in the equation:

$$C_{air} = \alpha \cdot C_{vap} \cdot 1,000,000 \text{cm}^3 \text{m}^{-3}$$

Where:

$C_{air}$  is the concentration of vapours within the building,  $\text{mg}^{-3}$

$\alpha$  is the steady state attenuation coefficient between soil and indoor air, dimensionless

$C_{vap}$  is the soil vapour concentration,  $\text{mgcm}^{-3}$

The target concentrations within indoor air for each substance ( $C_{air}$ ) are a function of receptor inhalation rates and occupancy periods, as defined by the site conceptual exposure model (assuming standard CLEA occupancy periods and receptors).

The attenuation factor was calculated using J&E (Equation 10.4 in SR3) and the resulting  $C_{vap}$  is equivalent to the  $GAC_{sv}$  for the modelled exposure scenario.

Where the calculated  $GAC_{sv}$  for a substance exceeds the vapour saturation limit, no  $GAC_{sv}$  has been proposed.

## INHALATION OF GROUNDWATER-DERIVED VAPOURS

The CLEA model does not have the capacity to derive GACs to assess vapours derived from dissolved phase contamination. WSP has derived a set of groundwater GACs ( $GAC_{gw}$ ) to evaluate the potential risks through the indoor inhalation of groundwater-derived vapours by first applying the approach described above for the derivation of the WSP  $GAC_{sv}$  to determine the acceptable concentration in soil vapour directly above the water table.

The depth to groundwater was assumed to be 1 m bgl (i.e. 0.85 m below the base of the building foundation). This depth was considered to be more representative of commonly encountered groundwater conditions than the 0.5 m below the base of the building foundation (i.e. 0.65 m bgl) that is used by CLEA for an unsaturated source present in the overlying soil.

The  $GAC_{gw}$  was then back-calculated from the  $GAC_{sv}$  using the air-water partition coefficient ( $K_{aw}$ ) for each substance.

Where the calculated  $GAC_{gw}$  for a substance exceeds the solubility limit, no  $GAC_{gw}$  has been proposed.

## UK APPROACH

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### THE LEGISLATION

#### OVERVIEW OF POINTS PERTINENT TO CONTROLLED WATERS RISK ASSESSMENT

The EU Water Framework Directive 2000/60/EC (WFD) is designed to:

- Protect, improve and enhance the status and to prevent further deterioration of aquatic ecosystems and associated wetlands which depend on the aquatic ecosystems.
- Promote the sustainable use of water.
- Reduce and reverse all pollution of water, especially by 'priority' and 'priority hazardous' substances.

River Basin Management (RBM) Plans are part of the WFD strategic framework and are based on detailed analysis of the impacts of human activity on the water environment. They are designed to protect and improve the quality of our water environment and are reviewed and updated every six years. They include improvement measures to progress all ground and surface water bodies to 'Good' status by 2021. The latest system of standards and classification are set out in the 2015 Directions for England and Wales<sup>1</sup> and Scotland<sup>2&3</sup>, and also listed for Scotland in WAT-SG-53<sup>4</sup>.

The EU Groundwater Daughter Directive 2006/118/EC (GWDD) further protects groundwater. It states that hazardous substances must be prevented from entering groundwater and that non-hazardous substances should be limited from entering groundwater to concentrations that do not cause pollution.

The Environmental Quality Standards Directive (EQSD), also known as the Priority Substances Directive 2008/105/EC (PSD) as amended by 2013/39/EU, further protects surface waters and defines Environmental Quality Standards for hazardous and non-hazardous substances in surface waters.

#### GROUNDWATER BODY CLASSIFICATION

Groundwater bodies are classified on their quantitative and chemical status. The quantitative status is not generally relevant to controlled waters risk assessments. The chemical status requires analytical data collected by the Environment Agency (EA), Natural Resources Wales (NRW) and the Scottish Environment Protection Agency (SEPA) across the water body to be evaluated against five sets of Threshold Values which are used by the regulators to decide if further, specific evaluation is required. They are not used to classify the groundwater bodies' chemical status and the 2014 and 2015 Standards Directions state that they should not be used as part of site-specific investigations.

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<sup>1</sup> The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

<sup>2</sup> The Scotland River Basin District (Standards) Directions 2014

<sup>3</sup> The Scotland River Basin District (Standards) Amendment Directions 2015

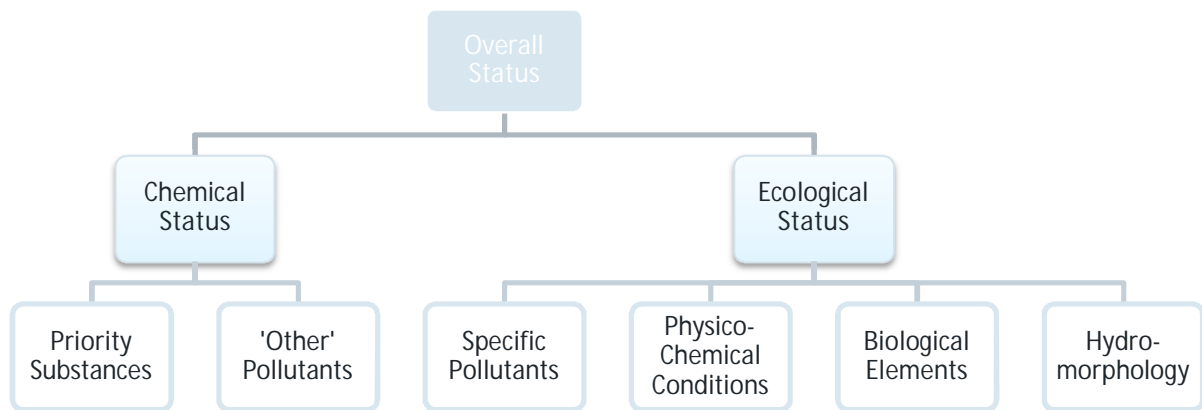
<sup>4</sup> SEPA 'Supporting Guidance (WAT-SG-53): Environmental Quality Standards and Standards for Discharges to Surface Waters' v6. December 2015

## SURFACE WATER BODY CLASSIFICATION

Environmental Quality Standards (EQSs) are used by the EA, NRW and SEPA to characterise, monitor and classify water bodies and to help these regulators establish measures to progress all water bodies to 'Good' status. For surface water bodies the following applies:

- Chemical status is determined on a 'Good' or 'Fail' basis.
- Ecological status is determined on a scale of 'High', 'Good', 'Moderate', 'Poor' and 'Bad'.
- The overall ecological status is determined by the lowest classification of all the parameters that are assessed.
- For an overall 'Good' status both ecological and chemical status must be at least 'Good' (see **Figure 1**).

**Figure 1 – Elements of Water Body Status Classification**



**Priority substances** – are defined by the European Commission (EC) and are reviewed every six years to ensure they stay relevant and that EQSs are up to date.

**Other pollutants** – not priority substances, but defined by the EC and the EQSs are identical to those laid down in legislation applied prior to 13 January 2009.

**Specific pollutants** - European Union (EU) Member states are required to identify nationally significant pollutants to support the assessment of 'Good' ecological status.

**Physico-chemical conditions** - includes parameters such as dissolved oxygen, pH, ammonia and phosphate that define the general chemistry of the surface water body and may influence the degree to which an aquatic ecosystem can thrive.

**Biological elements** – the condition and abundance of fish and invertebrates within the surface water body including the presence of invasive species.

**Hydromorphology** – includes water flow, sediment composition and the structure of the habitat and its ability to support an aquatic ecosystem.

## GUIDANCE ON THE SELECTION OF ASSESSMENT CRITERIA

The Remedial Targets Methodology (RTM)<sup>5</sup> is the framework for controlled waters risk assessment which is used in England and Wales. The equivalent document used for the water environment in Scotland is WAT-PS-10-01<sup>6</sup>. Although the RTM preceded the formal adoption of the WFD in England and Wales, the document was cognisant of the requirements of the forthcoming WFD i.e. no discernible entry of hazardous substances into groundwater bodies, and no new pollution by non-hazardous substances. The methodology for the selection of assessment criteria in both documents states that where a hazardous substance is present in the soil beneath the site but is yet to enter groundwater, no discernible entry of that hazardous substance into groundwater is allowed. This effectively requires the allowable concentration of the contaminant of concern within the groundwater body to be either background or the limit of detection. The EA and SEPA use a published set of Minimum Reporting Values (MRVs) to support the assessment of 'discernible entry'.

With respect to groundwater, where a hazardous substance has already entered the groundwater body to a discernible level, the regulators generally allow appropriate quality standards to be used to quantify the risk to allow pragmatic remedial targets and to take into account the requirements of other legislation such as Part 2A and NPPF.

Where non-hazardous pollutants enter groundwater, no new pollution (or substantial risk of pollution) of groundwater is allowable and quality standards are generally an acceptable concentration.

Where the receptor is a surface water body or groundwater-dependent terrestrial ecosystem quality standards are acceptable irrespective of whether the substance is hazardous or non-hazardous.

Both RTM and WAT-PS-10-01 state that any standard used should be relevant to the current or intended use of the aquifer and that they should be 'fit for purpose' in terms of the specific period of time over which they should be measured.

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<sup>5</sup> EA *'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination'* 2006.

<sup>6</sup> SEPA *'Position Statement (WAT-PS-10-01): Assigning Groundwater Assessment Criteria for Pollutant Inputs'* v3.0, August 2014.





## WSP APPROACH

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### OVERVIEW

WSP follows the RTM approach in England and Wales and the WAT-PS-10-01 approach in Scotland to assess the potential or actual risks to water bodies on sites that it investigates. In deriving a hierarchy of assessment concentrations with which to quantify the risks, WSP uses relevant EU and UK legislation and World Health Organisation (WHO) guidance, considers the background quality of the water resources and takes account of the current and feasible future uses of the resource. In Scotland the assessment concentrations are referred to as '*assessment limits*' and in England as '*target concentrations*'.

For all substances that are detected in groundwater, the quantitative risk assessment is undertaken by comparing the modelled or actual concentration in water to an appropriate published standard where one is available; this is the target concentration / assessment limit. The selection of the standards is described in further detail in the following Sections.

Where hazardous substances are either detected in soil leachates or are calculated using theoretical partitioning equations, an evaluation is undertaken to determine if discernible concentrations have entered the groundwater. This information is used to determine the most appropriate target concentration / assessment limit to adopt with which to evaluate the potential risks from the contaminants in the unsaturated zone. Where no published standards are available, WSP determines on a case-by-case basis whether site-specific or chemical-specific targets should be derived through additional research or studies.

WSP seeks to ensure that the best available limit of detections (LOD) are achieved for analysis that it commissions. Where this is the case and the LOD is greater than a published target standard, WSP will not conclude that a potential risk exists to the relevant water body. This is in line with the approach that the EA and SEPA take in determining the classification status of the water bodies.

### APPROACH TO HAZARDOUS SUBSTANCES

For sites in England and Wales, WSP evaluates the soil leachate analytical results or theoretical partitioning calculations for hazardous substances as listed on the EA website<sup>7</sup> (updated 13 January 2017). For sites in Scotland, the MRVs provided in Annex 4 of WAT-PS-10-01 are used and these are the same as those produced by the EA. Where an MRV is not available, the limit of detection is used for hazardous substances.

Where groundwater analytical results are also available these are evaluated alongside the unsaturated concentration data to determine if the hazardous substances have entered the groundwater by a discernible amount (taken to be the MRV or limit of detection). If hazardous substances are detected in the groundwater, then the quantitative risk assessment of the soil concentrations continues using published standards appropriate for drinking water (see '*Impact to Drinking Water*' below). If the hazardous substances have not yet entered the groundwater, then the soil concentrations are evaluated using the MRVs/LODs.

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<sup>7</sup> <https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values>

## IMPACT TO AQUATIC LIFE IN SURFACE WATERS

Although the surface water EQSs are primarily designed to support the EA and SEPA in their programmes of classification and monitoring of the quality of surface water bodies across England, Wales and Scotland under their WFD and EQSD obligations, the EQSs are also commonly used by contaminated land professionals to quantitatively evaluate the potential impact of site-specific ground contamination to surface waters. This approach is also suggested in RTM and WAT-PS-10-01.

The 2014 and 2015 Standards Directions provide EQSs for the assessment of ecological and chemical surface water body status. When quantifying potential impacts to surface waters, WSP's approach is to focus on the chemical status by evaluating the 'priority' and 'other' pollutants that are listed in those Directions. In addition, the 'specific' pollutants, (which are actually part of the evaluation of ecological status), are also assessed. These three classes of pollutants are used by the EA to mark the boundary between a Good status surface water and failing quality. As such, exceedances of these EQSs can be considered to highlight a potential risk that the surface water will not achieve or maintain its 'Good' status, which contravenes the requirements of the WFD. WSP adopts this approach irrespective of whether the EA or SEPA has determined if the surface water body requires an assessment of chemical status or not, so as to ensure that the requirements of the WFD are met for all surface water bodies that it evaluates in the context of ground contamination.

The EQSs are designed to be applied over a specific period of time. WSP selects the annual average or long term mean as the target concentration for each priority substance, specific pollutant and other pollutant. In most cases, the number of groundwater sampling events will be limited and as such, there are limitations to this approach that WSP highlights on a case by case basis.

A number of EQSs do not come into force until 22 December 2018. WSP may use these values because they can be used as an indicator of long term contamination issues that may pose issues for a site in the near future. This is determined on a case-by-case basis.

Maximum Allowable Concentration (MAC) EQSs are designed to assess acute exposure of the aquatic environment to pollutants. As such, WSP does not consider the use of MACs to be appropriate to use as a target concentration in the majority of cases. An exception could be the evaluation of potential ecological risks to a surface water from a one-off catastrophic spill or leak in an emergency response scenario.

WSP does not assess the potential ecological risks posed by physico-chemical quality elements on a regular basis. pH, dissolved oxygen, biological oxygen demand, acid neutralising capacity, phosphorus, temperature and salinity are considered too unstable to be modelled from groundwater to surface water and these parameters are only measured in the receiving surface water body.

Where a published EQS is not available, WSP follows the WAT-PS-10-01 guidance for sites in Scotland and applies non-WFD EQSs. These comprise repealed Dangerous Substances Directive (DSD) substances as well as EQSs from other sources that should be used with caution. For sites in England and Wales, WSP uses the EA's operational environmental quality standards for Environmental Permitting which are essentially the repealed DSD substances that are applied in Scotland. WSP uses the proposed ethylbenzene EQS from R&D Technical Report P2-115/TR4 2002<sup>8</sup> for sites in England and Wales. This is equivalent to the SEPA non-statutory EQS.

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<sup>8</sup> EA 'Proposed Environmental Quality Standards for Ethylbenzene in Water' R&D Technical Report P2-115/TR4. 2002.



With respect to petroleum hydrocarbons, WSP refers to the CL:AIRE 2017 guidance<sup>9</sup> in order to derive alternative assessment criteria. In cases where no equivalent VOC, SVOC or PAH data is available, the following proxy compounds are used:

- Aromatic EC5-EC7 benzene (EC6.5)
- Aromatic >EC6-EC7 benzene (EC6.5)
- Aromatic >EC6-EC8 benzene (EC6.5)
- Aromatic >EC7-EC8 toluene (EC7.6)
- Aromatic >EC8-EC10 ethylbenzene (EC8.5)
- Aromatic >EC10-EC12 naphthalene (EC11.7)
- Aromatic >EC12-EC16 naphthalene (EC11.7)
- Aromatic >EC16-EC21 anthracene (EC19.4)
- Aromatic >EC21-EC35 benzo(a)pyrene (EC31.3)

## IMPACT TO DRINKING WATER

### ABSTRACTION FOR PUBLIC POTABLE SUPPLY

In line with the RTM and WAT-PS-10-01, WSP uses drinking water quality standards to evaluate the potential risk to aquifers from both the perspective of current abstraction for potable supply and also to evaluate the risk to future resource potential. The sources of drinking water standards are applied by WSP in the following hierarchy with the UK Drinking Water Standards (DWS) as the first tier:

- UK Water Supply (Water Quality) Regulations of England, Wales and Scotland
- EC Drinking Water Directive 1998
- WHO Drinking Water Guidelines 2011
- WHO Petroleum Products in Drinking Water 2008

RTM does not advocate country-specific standards outside the UK.

In Scotland, SEPA's published Resource Protection Values (RPVs) use the published US EPA National Primary Drinking Water Regulations where they are more conservative than the WHO standards. Where no RPV exists, WSP applies the remainder of the WHO standards as a second, non-statutory tier.

### ABSTRACTION FOR PRIVATE SUPPLY

*The Private Water Supplies Regulations* of England, Scotland and Wales prescribe maximum concentrations and values of inorganic and organic constituents as well as radioactivity and bacteria for natural waters intended for private supply. The concentrations and values are the same as those for public potable supply.

### ABSTRACTION FOR BOTTLED WATER

*The Natural Mineral Water, Spring Water and Bottled Drinking Water Regulations* of England, Scotland and Wales prescribe maximum concentrations and values of inorganic and organic constituents as well as radioactivity and bacteria for natural waters intended for sale for human consumption.

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<sup>9</sup> CL:AIRE 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies' v1.1 March 2017.

## OTHER RECEPTORS

WSP also considers other less common controlled waters receptors, where applicable, including but not limited to:

- *The Bathing Water Regulations 2013* which provides standards for the classification of the quality of bathing waters at specified locations on the basis of intestinal enterococci and *E. coli* levels.
- *WAT-SG-53, Table 9a: Operational Standards for Aquaculture* which provides the operational water quality standards used by SEPA for regulating the use of chemicals in aquaculture.