

Appendix H

Generic Notes – ID Geoenvironmental Investigations

Environmental Setting

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority and the Local Authority etc is presented in the Correspondence Appendix of this Geoenvironmental Report.

Geology, Mining & Quarrying

In order to establish the geological setting of a site, ID Geoenvironmental refer to BGS maps for the area, and the relevant geological memoir.

A coal mining report is obtained from the Coal Authority. Further information is sourced from the Local Authority and by reference to current and historical OS plans.

Landfills and other Historical Land Uses

ID Geoenvironmental obtain data from the Landmark Information Group, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Historical maps dating from the middle of the nineteenth century are also studied for evidence of historical land uses (i.e. gas works, foundries, chemical works) which may represent potential sources of contamination or ground instability.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move through fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, ID Geoenvironmental refer to BRE Report BR211, 2007: "*Radon: guidance on protective measures for new buildings*".

The level of protection needed is site-specific and is determined by reference to the maps contained in Annex A of BR211. These maps are derived from the Radon Atlas of England and Wales (2007), and indicate the highest radon potential within each 1km grid square.

If the site falls within a light grey square on the relevant map in Annex A then basic radon protection should be installed in new buildings; if the site falls within a dark grey square then full radon protection should be installed. **If the site is in an un-shaded square then no radon protection is needed.**

BR211 provides a preliminary indication of the measures required for a particular site, but it is also often beneficial to request a BR211 Radon Report from the BGS. The Annex A maps indicate the highest geological radon potential within each 1km grid square, but in many cases the radon potential varies considerably within the grid square. The BR211 Radon Report gives definitive guidance on the requirement for radon protective measures, and therefore may allow the adoption of a lower level of protection than that indicated in the Annex A maps.

ID GeoEnvironmental typically obtain a BR211 Radon Report for all sites that fall within a shaded square on the relevant Annex A map.

When requesting a BR211 Radon Report from the BGS ID GeoEnvironmental select the search radius carefully, since too large a search radius may result in the inclusion of areas of higher geological radon potential, and therefore in the recommendation of too high a level of protection.

Further details of the protective measures required, if appropriate, are provided in the Hazardous Gas section of this GeoEnvironmental Report.

Hydrogeology

ID GeoEnvironmental obtain information from the Environment Agency (EA) and the Landmark Information Group with respect to:

- groundwater quality
- recorded pollution incidents
- licensed groundwater abstractions

From 1 April 2010 the Environment Agency's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetland ecosystems.

The aquifer designation data is based on geological mapping provided by the British Geological Survey.

These maps are split into two differing aquifer designations:

- **Superficial (Drift)** – permeable unconsolidated (loose) deposits such as sands and gravels.
- **Bedrock** – solid permeable formations such as sandstone, chalk or limestone.

The maps display the following aquifer designations:

- **Principal aquifers:** *"These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer".*
- **Secondary A** – *"permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers";*

- **Secondary B** - *predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers*
- **Unproductive Strata:** *These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow. However groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some non-aquifers can yield water in sufficient quantities for domestic use”.*

Groundwater vulnerability is determined by 4 variables:

1. The presence and nature of overlying soil (the weathered zone affected by living organisms; soil in the UK can extend up to 2m in depth). Physical properties of the soil affect the downward passage of water and it's ability to attenuate pollutants. The EA make reference to a three-fold classification of soil types:-
 - Soils of **low** leaching potential are defined as *"soils in which the pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants”.*
 - Soils of **intermediate** leaching potential are defined as *"soils which have a moderate ability to attenuate diffuse source pollutants or in which it is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer”.*
 - Soils of **high** leaching potential are defined as *"soils with little ability to attenuate diffuse source pollutants and in which non-adsorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater”.*

In urban areas and restored mineral workings the soil information is based on fewer observations than elsewhere. A worst-case vulnerability (H) is therefore assumed for these areas and for current mineral workings by the EA. All are given a designation of **HU** unless proved otherwise.

2. The presence and nature of Drift, which often overlies bedrock. Where Drift is of substantial thickness and low permeability, it can provide an effective barrier to surface pollutant migration. Permeable Drift is classified as a Minor Aquifer except where it is in probable hydraulic continuity with a Major Aquifer, where it is regarded as part of the Major Aquifer unless proven otherwise by site investigation.
3. The nature of the geological strata (bedrock). Rocks that contain groundwater in exploitable quantities are called aquifers.
4. The depth of the unsaturated zone; i.e. that part of the aquifer which lies above the water table

The EA have also designated Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

ID GeoEnvironmental obtain information from the Environment Agency and the Landmark Information Group with respect to:

- surface water quality
- recorded pollution incidents
- licensed abstractions (groundwater & surface waters)
- licensed discharge consents
- site susceptibility to flooding

The EA have set **water quality** targets for all rivers. These targets are known as River Quality Objectives (RQO's). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are six GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to **flooding** is assessed by reference to a Flood Map on the Environment Agency's website. These maps provide show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.

There are two different kinds of area shown on the Flood Map:

1. Dark blue areas could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year
2. Light blue areas show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year (or 1 in 200 year as appropriate), areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year

flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist consultant who can advise on appropriate mitigating measures; ie raising slab levels, provision of storage etc.

Furthermore, as discussed in Planning Policy Statement 25 (PPS25) a consequence of amendment 8 to Article 10 of The Town and Country Planning (General Development Procedure) Order 1995 ("the GDPO"), on 1st October 2006, LPAs are required to consult the Environment Agency on all applications for development in flood risk areas (except minor development), including those in areas with critical drainage problems and for any development on land exceeding 1 hectare outside flood risk areas.

COMAH & Explosive Sites

ID GeoEnvironmental obtain information from the Landmark Information Group with respect to COMAH or explosive sites within 1km of the proposed development site. MMi's report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary Conceptual Ground Model

The site's environmental setting (and proposed end use) is used by ID GeoEnvironmental to assess the significance of any contamination encountered during the subsequent ground investigation

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential targets.

Potential pollutant linkages are shown on a preliminary conceptual site model, presented as a Drawing in an Appendix to this Geoenvironmental Report. The preliminary model is revised in light of data arising from the subsequent ground investigation.

Generic Notes 2.

Ground Investigation Fieldwork

General

IDG Ground Investigations are undertaken in accordance with current UK guidance including:

- *BS EN 1997-1:2004 Eurocode 7: Geotechnical design — Part 1: General rules*
- *BS EN 1997-2:2007 Eurocode 7: Geotechnical design —Part 2: Ground investigation and testing*
- *NA to BS EN 1997-2:2007 UK National Annex to Eurocode 7. Geotechnical design. Ground investigation and testing*
- *BS 5930:1999 Code of practice for site investigations (partially replaced, under revision).*
- *BS 10175:2011 Investigation of potentially contaminated sites. Code of practice.*
- *BS EN ISO 14688-1:2002 Geotechnical investigation and testing. Identification and classification of soil. Identification and description.*
- *BS EN ISO 14688-2:2004 Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification.*
- *BS EN ISO 14689-1:2003 Geotechnical investigation and testing. Identification and classification of rock. Identification and description.*
- *“Guidance on the protection of housing on contaminated land” – NHBC & EA R&D Publication 66 (2000, 2008) updated 3rd June 2014*
- *“Technical Aspects of Site Investigation” – EA R&D Technical Report P5-065/TR (2000)*
- *“Development of appropriate soil sampling strategies for land contamination” – EA R&D Technical Report P5-066/TR (2001)*
- *AGS: 1996 “Guide to the selection of Geotechnical Soil Laboratory Testing”*

Exploratory hole logs are presented in Appendices to this Geoenvironmental Report. These logs include details of the:

- Investigation technique adopted
- Descriptions of the solid strata, and any groundwater encountered.
- Samples taken
- Results of any in-situ testing
- Any gas\groundwater monitoring well installed

Exploratory Hole Locations

Exploratory hole locations are selected by IDG, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation Techniques

Ground conditions can be investigated by a number of techniques. Techniques most commonly used by IDG include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket.
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing. Cable Percussive drilling is employed to advance boreholes in superficial (made ground and Drift strata).
- Window or Windowless Sampling boreholes. Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm) diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material) and cannot be used in solid strata.
- Rotary percussive open-hole probeholes are typically drilled using a tricone rock roller bit with water or air as the flushing medium. Rotary probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse. Rotary boreholes are used to enable progress in solid strata (rockhead) and are commonly drilled to identify the presence of shallow mineworkings or to install deep groundwater monitoring boreholes in the solid strata.

Hazardous ground gas and groundwater monitoring boreholes may be installed in cable percussive boreholes, window sample probeholes and rotary boreholes. Where installed, gas\groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10 mm diameter non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a circular or square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter raised steel helmet set in concrete, which stands approximately 300mm proud of ground level.

Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ Testing

Where relative densities of granular materials given on the trial pit and window sample logs are based on visual inspection only, they do not relate to any specific bearing capacities.

BS EN ISO 22476-3:2005 Geotechnical investigation and testing. Field testing. Standard penetration test

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS EN ISO 22476-3:2005. The sampler is penetrated over an initial seating drive of 150mm. The sampler is then driven for a test drive of 300mm in four increments of 75mm. The total number of blow required to drive the sampler 300mm is recorded as the penetration resistance or N-value. Where full penetration (450mm) is not possible the test is continued up to a maximum of 50 blows and the depth of penetration is recorded in millimetres.

The strength of cohesive deposits is determined using a hand shear vane in general accordance with BS1377-7-1990.

Shear strength test results reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Representative soil/fill samples are taken at regular intervals from the exploratory holes to assist in description of the ground and to allow selected laboratory testing to be performed. The type of sample taken is dependent on the nature of the stratum and the purpose of the analysis.

Where the soils encountered contain a significant proportion of coarse grained material, truly representative samples are not typically obtained and only the finer fraction is placed in sample containers. However, a visual estimate of the amount of coarse material is made on site. Note: Coarse constituents not sampled are defined as: coarse gravel, cobble and boulder. (i.e. any 'particles' with an average diameter greater than 20mm).

Occasionally, unrepresentative 'spot' samples are also taken from some exploratory locations for contaminant analysis, typically where unusual, localised pockets of materials are encountered.

Samples of soil for chemical testing are placed into appropriate containers (see below) prior to delivery to the selected laboratory. Samples of water are taken in one litre, brown glass bottles and stored in cool boxes, at a temperature of approximately 4°C, until delivery to the selected laboratory. Soil/fill samples for organic analysis are also stored in cool boxes.

Sample Containers (for geotechnical analysis). The majority of samples are only scheduled for PI and sulphate testing, for which 500g of sample is required (a full 0.5-litre plastic tub). However, bulk bags are taken where scheduling of compaction or grading tests are required.

Containers (for contaminant analysis). In order to comply with MCERTS requirements, labs have to provide a sample description and consequently require sufficient soil sample, and the use of wide-necked containers. For any sample requiring both inorganic & organic analysis, it is necessary to submit both a 1-litre glass jar and a 1 kg plastic tub.

Where scheduling for VOC (including GRO) testing is anticipated, a glass vial is also required. In summary (for contaminant analysis):

Anticipated testing	Container(s)	Remarks
pH & metals only	1 kg plastic tub	
organics (TPH, PAH) etc only	1 litre wide-necked glass jar	Vial required if TPH is to include GRO as well as DRO & LRO, or speciated PAH
VOCs (incl. naphthalene and/or GRO) only	glass vial & 1kg plastic tub	
pH & metals, and organics	1 litre wide-necked glass jar 1kg plastic tub	

pH & metals, and organics (incl. VOCs or GRO)	glass vial 1 litre wide-necked glass jar 1kg plastic tub	
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Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during the ground investigation.

Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

Description of Strata

Soils encountered during an IDG investigation are described (logged) in general accordance with EN ISO 14688-1. The descriptions and depth of deposits encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section of the report within the main body of text.

Rocks encountered during an IDG investigation are described (logged) in general accordance with EN ISO 14689-1. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section of the report within the main body of text.

The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to Exploratory Hole Logs

Keys to logs are presented in the Appendix(ces) containing the logs. There are two Keys – Symbols & Legends and Terms & Definitions.

Generic Notes – ID Geoenvironmental Investigations

3. Geotechnical Laboratory Tests

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by IDG. All tests are carried out in accordance with BS 1377:1990.

The test results are presented as received in an Appendix to this Geoenvironmental Report.

The following laboratory testing are routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading.
- Compaction tests
- Particle density.

Atterberg Limits & Moisture Content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. IDG typically only consider a soil to be shrinkable if the proportion finer than 63µm is >35%.

PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'_p), defined as:

$$I'_p = I_p * (\% < 425\mu\text{m} / 100)$$

ie if PI is 30%, but the soil contains 80% < 425µm, then: $I'_p = 30 * 80/100 = 24\%$.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs.

IDG apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- the average values for each particular soil type (ie differentiate between residual soil and alluvium),
- the number of results in each class and
- the actual values.

Unless the judgment strongly indicates otherwise, IDG typically adopt a conservative approach and recommend assumption of the higher classification.

Soluble Sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

IDG refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2005). SD 1 provides definitions of:

- the nature of the site (greenfield, brownfield or pyritic)
- the groundwater regime (static, mobile or highly mobile)
- the Design Sulphate Class (DC Class) and
- the Aggressive Chemical Environment for Concrete (ACEC Class)

IDG reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Generic Notes – ID Geoenvironmental Investigations

4 Contamination Laboratory Analysis & Interpretation (including WAC)

Current UK Guidance

The UK approach to contaminated land is set out in **Land Contamination Risk Management (LCRM)** published on the Gov.uk website. The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source, (2) a receptor (eg controlled water or people exposed to the contaminants) and (3) a pathway linking (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

As recommended by LCRM, IDG adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. In general this comprises the following elements of work:

- A Preliminary Risk Assessment (PRA)
- A Generic Quantitative Risk Assessment (GQRA)
- A Detailed Quantitative Risk Assessment (DQRA)

Preliminary Risk Assessment

A preliminary risk assessment is generally undertaken as part of a “Desk Study” investigation. This investigation collates readily available information including historical land uses, the geological, hydrogeological and hydrological setting of the site, and the proposed end-use which is presented as a “Preliminary Conceptual Model”. Potential pollutant linkages are defined and a preliminary assessment of the risks posed to receptors is stated.

Further information regarding the development of a conceptual model for the site is presented in Generic Notes 1 – Environmental Setting and Preliminary Risk Assessment.

Generic Quantitative Risk Assessment

Where potential pollutant linkages are identified in the preliminary conceptual model a generic quantitative risk assessment (GQRA) generally forms part of an intrusive phase of site investigation, allowing for the sampling of both soil and groundwater. The intrusive investigation should target pollutant linkages identified in the Preliminary Conceptual Model, but should also investigate previously unidentified sources and contaminant pathways encountered during the site investigation works.

Human Health

Detailed guidance on human health risk assessment is available in the following:

- INFO-RA2-2: assessing risks to human health
 - Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
 - Updated technical background to the CLEA model - Science Report: SC050021/SR3
 - CLEA Software (Version 1.05) Handbook Science report: SC050021/SR4
 - Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008

Generic Assessment Criteria represent “screening concentrations” devised for a number of standard land-use scenarios. They are based conservative receptor and exposure parameters and provide a useful method of screening out sites where contaminants pose a negligible risk. GACs are available from a number of sources for the following land-use scenarios. These scenarios include:

- Residential end-use with consumption of homegrown produce.
- Residential end-use without consumption of homegrown produce.
- Residential Public Open Space (Landscaped Areas)
- Public Open Space (Parks)
- Allotments
- Commercial Development

The initial step of such a generic quantitative risk assessment is to compare site chemical data with appropriate UK generic assessment criteria. These following GACs are currently appropriate.

- Soil Guideline Values (SGVs) (Environment Agency 2009) are based on CLEA “default settings and therefore represent screening criteria based on minimal risk to human health. SGVs are available for arsenic, cadmium, mercury, nickel, selenium, BTEX, phenols and dioxins, furans and dioxin-like PCB substances for residential, allotments and commercial land-uses based on a sandy loam soil and a 6% soil organic matter (SOM) content.
- Soil Generic Assessment Criteria for Human Health Risk Assessment (EIC/AGS/CL:AIRE 2009) adopted CLEA default settings and therefore represent screening criteria based on minimal risk to human health. GACs were derived for 3 metals and 32 organic contaminants for four standard land uses at 1%, 2% and 6% SOM content.
- Suitable for Use Levels (S4ULs) (LQM/CIEH, Nathanail 2015) represent generic assessment criteria for each of the above standard land-uses, based on updated toxicological assessments and modified exposure parameters. They therefore represent screening criteria based on minimal risk to human health. S4ULs for organic compounds are available for 1%, 2% and 6% SOM. (*S4ULs Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3061. All rights Reserved.*)
- Category 4 Screening Levels (Defra March 2014) are primarily intended to be used to assist the classification of land under the revised Part 2A Statutory Guidance issued in 2012. The revised guidance introduced the concept of four categories of contaminated land (Category 1 (significant/high risk) – Category 4 (low risk). C4SLs are low risk levels which are not representative of significant possibility of significant harm (SPoSH) and, whilst not intended to mark the top of Category 4, should the C4SLs not be exceeded, land can be demonstrated as being in Category 4 and cannot be determined as contaminated land.

The GAC selected to form the basis of a Generic Risk Assessment are dependent on the existing or proposed land use as defined in the Conceptual Model (which identifies the critical receptor and exposure parameters) and other factors such as the SOM content of the near surface soils at the site.

Soil organic matter (SOM) is the fraction of soil composed of organic matter. It consists principally of decomposed plant remains. The presence of SOM is important in determining the fate and behaviour of a number of organic contaminants. Generally, the greater the SOM content of soil, the greater the sorptive capacity of the soil and the lower the mobility of certain contaminant phases. (Note: $TOC = SOM \times 0.58$; and $FOC = TOC/100$).

Generic Assessment Criteria adopted by IDG available, by regulators, upon request.

The CLEA model assumes a simple linear partitioning between the sorbed, dissolved and vapour phases. The theoretical upper boundaries to this behaviour are represented by the maximum aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA model uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous or vapour based saturation limit (the lower saturation limit). Assessment criteria which exceed the lower of the two saturation limits and where the vapour pathway is an important contributor to exposure are highlighted in red in the CLEA model. These values are depicted as shaded values in the IDG GAC Tables. In such cases the exposure from the vapour phase will be over predicted and where the vapour pathway is the only exposure route being considered the risk is likely to be negligible.

IDG Reports will therefore state the applicable land-use scenario, and the SOM content adopted for the assessment. In general, the initial assessment **assumes a low soil organic matter content (1% SOM)** to ensure that the assessment is appropriately conservative. Where contaminant concentrations exceed the adopted GAC, site-specific assessment (for example applying measured SOM contents of soils or development site-specific exposure parameters) will be undertaken to further evaluate the risk. It should be noted that exceedance of GAC does not necessarily mean that remediation will be required.

Interpretation of Results

Prior to undertaking any comparison of soil contamination data, the issue of the averaging area requires further consideration. IDG consider that contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, IDG gather and analyse sample results by “soil type”, or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the averaging area is associated with the extent of a particular fill type, or an area affected by spillage/leakage rather than from within a specified depth below the site surface.

In terms of brownfield redevelopment, this is considered an appropriate methodology which provides a representative sample population for statistical analysis which allows for the necessary relocation of soils during site development works.

Should any of the GAC criteria detailed above be exceeded, then three possible courses of action could be considered. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

- Undertake further statistical analysis to determine whether contaminant concentrations of inorganic contaminants within soil/fill actually present a risk (only applicable to assessing the risk to human health).
- Based on a Generic Quantitative Risk Assessment, advocate an appropriate level of remediation to “break” the pollutant linkage - for example the removal/relocation of the contaminated materials or the provision of a clean cover.
- Carry out a more a Detailed Quantitative Risk Assessment in order to further assess the risk.

Controlled Waters Receptors

Where the environmental setting of a site is considered moderately or highly “sensitive” in respect of controlled waters (i.e where a pollutant linkage potentially exists to a controlled waters receptor) a risk assessment will be undertaken. This initially comprises comparison of soil-leachate or groundwater concentrations to the appropriate water quality standard. Depending upon the specific characteristics and environmental setting of the site the appropriate standard is likely to be one of the following:

- Water Supply (Water Quality) Regulations 1989

- Environmental Quality Standards: The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive)(England and Wales) Directions 2010.
- The Surface Waters (Abstraction for Drinking Water) Regulations

It is not possible to derive generic GAC values for controlled waters, because distance to the receptor, ground permeability and hydraulic gradient are key factors in the assessment, and both are extremely site-specific. As a consequence should groundwater or soil leachate concentrations exceed the adopted water quality standards in a site with moderate or high sensitivity, a detailed quantitative risk assessment may be required.

Phytotoxic Effects

With respect to the assessment of potential **phytotoxic effects** of contaminants, IDG refer to available publications relating to allowable concentrations of heavy metals (copper and zinc) in arable soils which have been set by the Department of Environmentⁱ. These values are detailed in the table below.

Allowable Concentrations of Heavy Metals in Arable Soils

Element	Limit According to pH of soil (mg/kg)			
	5.0 to <5.5	5.5 to <6.0	6.0 to 7.0	>7.0
Copper	80	100	135	200
Nickel	50	60	75	110
Zinc	200	200	200	300

IDG have reviewed the available data on Boron behaviour in soil, plant uptake and the relatively high precipitation rates typical in the UK. In the absence of any definitive value IDG have opted to be relatively conservative and have adopted a Boron Soil Screening Value of 5mg/kg. This value is considered protective of the majority of common landscape plants.

Hazardous Ground Gas

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents:

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating “traffic lights”. Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2006) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2007 – Code of Practice for the characterisation & remediation from ground gas in affected developments

Further information is presented in Generic Notes No. 5 – Hazardous Gas.

Waste Classification & WAC

Waste soils to be disposed off-site should be characterised by a general chemical testing for a broad suite to include pH, TOC, metals, speciated PAH and banded hydrocarbons. WAC testing is not required to characterise the waste. Chemical test result should be provided to the waste haulier and receiving landfill who will confirm the classification of the waste soils.

In the context of waste soils generated by remediation and/or groundwork activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated ‘natural’ soil, bricks, concrete, tiles & ceramics).

- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds).
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds).

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

From 16th July 2005, landfill operators require Waste Acceptance Criteria (WAC) laboratory data, should soil waste be classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

It should be noted that where non-hazardous waste is accepted at a non-hazardous landfill facility, WAC testing is not required.

Should off-site disposal of soils classified as hazardous waste be undertaken during redevelopment, then WAC analysis should be scheduled at an early stage in the remediation programme.

However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous. These contaminants can often be dealt with by alternative technologies (eg by bioremediation or stabilisation) and consequently retention on site is often possible.

Key References

Environment Agency (2008), "Evaluation of models for predicting plant uptake of chemicals from soil" Science Report – SC050021/SR.

Environment Agency (2008), "Human health toxicological assessment of contaminants in soil". Science Report – SR2.

Environment Agency (2009), "Updated Technical Background to the CLEA Model (as amended 2009)". Science Report - SC050021/SR3.

Environment Agency (2009), "CLEA Software (Version 1.05) Handbook". Science Report - SC050021/SR4.

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

CL:AIRE (2010), "Soil Generic Assessment Criteria for Human Health Risk Assessment".

CL:AIRE (2013), "Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. SP1010 Final Project Report.

DEFRA (2014), "Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination –. SP1010 Policy Companion Document.

Nathanial (*et. al.*) (2015). The LQM/S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham.

Department of Environment (1996), "Code of Practice for Agricultural use of Sewage Sludge".

Generic Notes – ID Geoenvironmental Investigations

5. Hazardous Gas

General

Hazardous gas is considered to be any mixture of potentially explosive, toxic or asphyxiating gases, most notably methane, carbon dioxide and oxygen (deficiency).

IDG Investigations are undertaken in accordance with the following Standards and Guidance:

- BS8576:2013 Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs).
- BS 8485:2015+A1:2019 Code of practice for the design of protective measures for methane and carbon-dioxide ground gases for new buildings.
- BS10175:2011 +A2-2017 Investigation of potentially contaminated sites – Code of practice.
- CIRIA C665 (2007) Assessing risks posed by hazardous ground gases to buildings.
- CIRIA C716 Remediating and mitigating risks from volatile organic compound (VOC) vapours from land affected by contamination.
- CIRIA 735 (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases.

In addition, radon, a naturally occurring radioactive gas is also considered. Further information about radon is included in Notes 1. – Environmental Setting.

At preliminary stage, the assessment of potential risks associated with hazardous gas are based on a review of data obtained from the Landmark Information Group/Groundsure Limited, and the Local Authority. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Sources

Potential sources of hazardous gas include:

- Landfill sites
- Made ground, especially where significant depths are present
- Shallow mineworkings associated with coal extraction
- Geological strata, including peat, organic silts, coal-bearing strata and limestone (reaction with acidic waters), granite (radon)
- Groundwater can sometimes act as a “carrier” for hazardous gas.
- Leakages from pipelines or storage tanks
- Sewers, septic tanks and cess pits

Generation

Wherever biodegradable material is deposited, landfill gas (principally a mixture of methane and carbon dioxide) is likely to be generated by microbial activity. Carbon dioxide is an asphyxiant and toxic; methane is

flammable and a mixture containing between 5% and 15% methane by volume in air is explosive. Landfill gas in the ground is unlikely in itself to pose a significant risk, though it may damage vegetation. However, infiltration of landfill gas into confined spaces (e.g. cellars, services, etc) may give rise to considerable risk.

There is no typical figure for the length of time that landfill gas will be evolved, but at many sites significant gas generation continues for at least 15 years after the last deposit of waste.

Migration

Gas migration from a landfill site may occur in several ways. It may migrate through adjacent strata; the distance of migration being dependent on the pressure gradients, volume of gas and permeability of the strata. Where there are faults, cavities and fissures within the strata, gas may move considerable distances. Other migration pathways for gas include man-made features such as mine shafts, roadways and underground services.

Gas migration is influenced by a number of climatic factors, such as atmospheric pressure variations, water table level variations and the influence of a covering of snow or ice over the surface of the site and surrounding area.

Gas Monitoring Procedure

IDG adopt a standard gas monitoring procedure. This procedure involves the measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration on site immediately prior to and on completion of monitoring.
- Borehole gas emission rate.
- Methane, oxygen and carbon dioxide concentrations using an infra-red gas analyser.
- Standing water level using a dipmeter.

In addition, ground conditions at each sampling location are recorded together with prevailing weather conditions and any other observations such as any vandalism.

Where samples of gas are required for laboratory analysis, Gresham Tubes or Tedlar Bags are used. Gas concentrations in the well are typically recorded immediately before and after retrieval of a sample.

Monitoring Programme

The appropriate length of the monitoring programme is confirmed in accordance with BS8576:2013 (Figure 6).

Site Characterisation

Gas monitoring results are assessed in accordance with BS8485:2015.

Borehole gas flow rates (Q_{hg}) are calculated for each gas at borehole standpipe for each monitoring event. On completion of the monitoring programme a GSV is adopted for the site taking into account the monitoring data, conceptual model, hazardous gas source(s) and nature of pathway. Where the dataset is representative and comprehensive, the GSV should be at the maximum borehole Q_{hg} measured for all the monitoring events.

A worst case check (based on site wide highest flow rate and site wide highest gas concentration) should also be calculated for the site. The worst case Q_{hg} should be compared with the maximum borehole Q_{hg} .

Characteristic gas situation (CS) is determined using the Q_{hg} adopted for the site in accordance with BS8485:2015.

Table 1 – Characteristic Situation BS8485:2015

Characteristic Situation	GSV CH ₄ or CO ₂ (l/hr)	Additional limiting factors	Typical source of generation
1	<0.07	Typically <1% methane concentration and <5% carbon-dioxide concentration (otherwise consider and increase to CS2)	Natural soils with low organic content
2	<0.07 to <0.7	Typical measured flow rate <70 litre/hr)otherwise increase to Characteristic Situation 3)	Natural soil, high peat/organic content
3	0.7 to <3.5	Quantitative Risk Assessment required to evaluate scope of protection measures.	Old landfill, inert waste, mineworking flooded.
4	3.5 to <15		Mineworking – susceptible to flooding, completed landfill, inert waste (WMP 26B criteria)
5	15 to <70		Mineworking unflooded, inactive
6	>70		Recent landfill site

Notes:

Borehole flow rate = volume of gas (regardless of composition) which is escaping from well (l/hr).

Gas Screening Value (litre/hour) = gas concentration (%) / 100 x borehole flow rate (l/hr).

Gas protection measures

A minimum “Gas Protection Score” is allocated for new buildings at the site. This is based on the characteristic situation of the site and the proposed building type. Low rise residential properties are generally classed as “Type A” buildings, whilst managed residential apartments are classed as “Type B buildings”.

The required gas protection measures, taking into account the proposed foundation and floor slab construction methods are selected to meet the required gas protection score. A combination of at least two of the following three types of gas protection measures are required to achieve the minimum gas protection score.

- The structural barrier of the floor slab, or of the basement slab and walls if a basement is present (Gas Protection Score 0-2.5).
- Ventilation measures (Gas Protection Score 0.5-4.0); and,
- Gas resistant membrane (Gas Protection Score 2). It is important to note that there are several requirements (including independent validation) that need to be fulfilled in order to achieve the score of 2.