Forest Research

SOIL SAMPLING DERELICT, UNDERUSED AND NEGLECTED LAND PRIOR TO GREENSPACE ESTABLISHMENT

BPG
NOTE 1
Best Practice Guidance for Land Regeneration

Tony Hutchings, Danielle Sinnett and Kieron Doick

Introduction

Soil sampling (Figure 1) is an expensive and time-consuming activity but the consequences are too perilous to be ignored. Good sampling design provides a cost-effective means of identifying site risks and liabilities which can seriously affect the overall success and sustainability of a site restoration. Poor sampling design can lead to insufficient identification and remediation of risks, for example where contamination is an issue, and result in devastating consequences to the environment or human health.

The Forestry Commission reclaims sites to improve environmental quality, with the majority of sites being reclaimed to improve the health and well-being of people and their communities. As such, community use is normally actively encouraged, and this presents the most compelling argument for getting the sampling right. If 'hotspots' of contamination are missed and receptors are harmed, then the site owner could face heavy financial litigation (through enforcement of Part IIA of the Environmental Protection Act 1990). Public confidence could be irreversibly affected.

At all stages of the site investigation process, professionals should not be afraid to conduct additional sampling whenever necessary. For example, where prior sampling has highlighted unforeseen risks or new potential risks, or where medium to high risk uncertainties have not been fully addressed.

Figure 1 Soil sampling: a hand-dug trial pit to investigate soil characteristics and profile depths.

Context and timing

Soil sampling should only take place once a site history has been ascertained and a conceptual model of environmental conditions and potential risks has been constructed and reviewed as part of a Preliminary Site Investigation Survey (Phase I). Soil sampling forms part of the intrusive site investigation (Phase II) and provides data for the processes of site evaluation and risk assessment. Subsequently, a risk management strategy is devised for all the identified risks (Phase III), or a site action plan may be devised, for example, for adjusting the soil conditions to suit vegetation establishment. As such, soil sampling and data interpretation should be undertaken by a suitably qualified experienced practitioner (such as a suitably qualified and experienced Environmental Consultant). An introduction into the site selection and risk assessment processes for identifying suitable locations for greenspace establishment is given in an FC Information Note (Doick and Hutchings, *Greenspace establishment on brownfield land: the site selection and investigation process*).

It is important to understand the difference between assessing for contamination under Part IIA of the Environmental Protection Act and assessing ground conditions for the purpose of site characterisation (such as nutrient deficiency) to determine the level of remediation required for successful plant growth. To keep costs down it is often preferable to take both sets of samples at the same time, although each will require its own set of specific laboratory analyses. Initial expenditure, prior to purchase or lease commitment, may be restrained by limiting the number of soil samples collected. However, it is likely that such deficiencies will need to be amended at later stages in order to generate a more complete understanding of the site conditions. Furthermore, it is worth remembering that it is relatively cheap to collect samples during a site investigation rather than to return to site at a later date, even if it is not the intention to immediately analyse all samples collected.

Best Practice Guidance Note 2: *Laboratory analysis of soils and spoils* deals with the analytical requirements for determination prior to vegetation establishment. The frequency of sampling and the type of sampling strategies that should be adopted are outlined below.

Sampling frequency

The objective of sampling is to address uncertainties about a site. Examples of when sampling may be required include: determining soil characteristics such as moisture retention properties or soil compaction across a site; locating potential contaminant sources; confirming the location of a suspected contamination source identified in the conceptual site model; determining plant nutrient or contaminant levels.

The number of samples that must be collected during a site investigation in order to address uncertainties will depend on several factors:

1. The purpose and hence requirements of the investigation, e.g. plant nutrient status, risk assessment, contaminant identification, and characterisation.
2. The degree of confidence and robustness that is required in the results such that defensible decisions can be made based upon the data obtained.
3. Site history and characteristics.
4. The stage of the investigation: preliminary or main investigation, overview or in-depth.
5. Sample heterogeneity or expected heterogeneity, e.g. of soil types, contaminants and contaminant concentrations, plant nutrients or hydrology.

In all cases, the number of samples taken should be sufficient to address the objectives for the investigation, including statistical analysis of the data. Guidance on sampling strategies (types of sampling) and minimum number of samples for potentially contaminated sites is given on pages 3 and 5, and worked examples (Case studies) are provided on pages 10–12.

What is a hotspot?

In the context of assessing a site that is suspected of being contaminated, a hotspot is an area where the contamination is at a level which has a medium to high risk of causing a significant pollutant linkage.

In the context of establishing vegetation on greenfield or brownfield sites, a hotspot could equally be defined as an area affected by compaction or of low plant available nutrients or high penetration resistance.

Hotspots are not necessarily static. For example, organic contaminants such as non-aqueous phase liquids (NAPLs, e.g. mineral oil) can leach through soils and affect groundwaters over comparatively short time periods. Sampling must therefore be conducted within a reasonable time from when decisions are to be made. This reinforces the fact that expert knowledge of possible pollutant linkages (i.e. a contaminant linked to a receptor(s) via a defined pathway) is required to determine optimum sampling strategies.

Types of sampling

There are two types of sampling:

1. Targeted: based on prior knowledge and professional judgement to investigate a given area.
2. Non-targeted: sets out a defined sampling pattern and spacing to investigate an area.

A combination of both targeted and non-targeted sampling should be used where there are obvious areas of potential contamination (targeted) and areas where contamination location is unknown (non-targeted).

Targeted sampling

Targeted sampling should only be employed where the conceptual site model has highlighted specific risks that the professional reviewer is confident can be resolved using a targeted sampling approach. For example, if the conceptual site model had highlighted a medium to high risk of pollutant linkage from a point source to a specified receptor and the exact whereabouts of both source and receptor were known, then a targeted sampling approach could be implemented to test if the pollutant pathway was significant.

Other examples where targeted sampling might be used include:

- Areas of stressed vegetation.
- Areas where surface water has collected which may indicate soil compaction.
- Very sensitive areas, e.g. planned picnic or children's play areas.

Non-targeted sampling

Non-targeted sampling should be used where an area is suspected of being contaminated, compacted or lacking in plant nutrients but insufficient knowledge is available to pinpoint the source, distribution or extent of the contamination, or the type or extent of nutrient deficiency. There are four commonly used patterns for non-targeted sampling (Figure 2) and specific examples where these could be used are given in Table 1. Where practicable a herringbone pattern of sampling should be employed as this is most efficient at taking into account site variability.

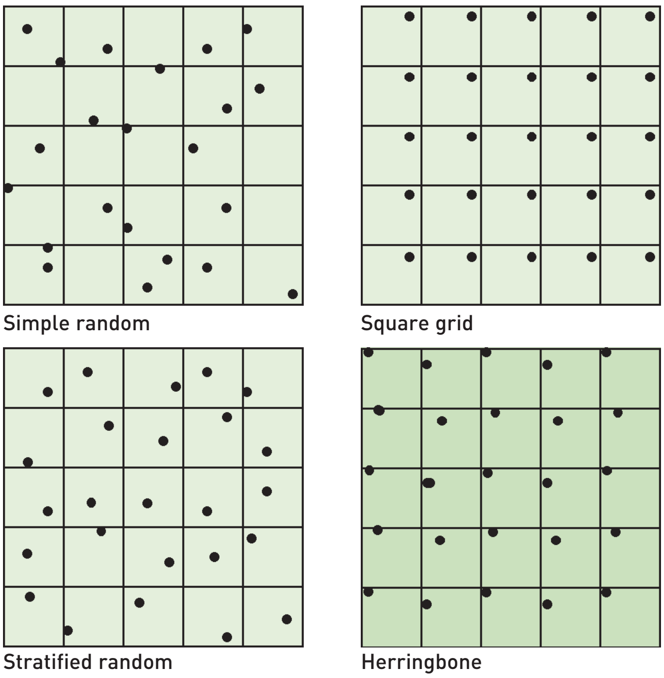

Figure 2 Non-targeted sampling patterns.

Table 1 Situations when non-targeted sampling would be appropriate (after Nathanail *et al.*, 2002).

When to use non-targeted sampling	Examples
Areas where there is a need to identify whether the land is contaminated	• Land where ownership or management is being transferred to another party
Where there is insufficient information on the location of contamination or to suggest that one area of a site is likely to be more contaminated than another	• Cleared or disturbed industrial site • Site which has had a multitude of former industrial uses
An area of a potentially contaminated site where little or nothing is known about the source of contamination	• Site with undocumented activities • Site with contamination migration from an external source
Areas where the distribution of contamination is expected to be random	• Landfill sites • Made ground • Validation of remedial works
Areas where the distribution of contamination is expected to be homogeneous	• Agricultural sites • Contamination associated with underlying geology
Areas where vegetation is exhibiting poor growth with no identified cause	• Contaminated sites • Nutrient deficient sites

Minimum number of samples

The spacing between sampling locations should be determined according to the investigation objectives. When assessing the suitability of a site for vegetation establishment, the sampling frequency will depend on such variables as site history and heterogeneity, whether assessment is to be made on the requirements for vegetation survival (e.g. nutrient availability) or likely constraints to establishment (e.g. phytotoxic contaminants or soil compaction). In such cases, a rule of thumb of minimum sampling frequency is generally considered to be 3 samples per ha. If, however, based on the Phase 1 investigations (the desk-top study and site walkover) there is strong reason to suggest that the site and its history can be characterised confidently, then there may be a strong argument to reduce the sampling frequency, e.g. to 1 sample per ha or fewer.

For potentially contaminated sites, sampling must be designed according to the conceptual site model, accommodating such information as known or suspected contaminant sources. The spacing between sampling locations should also be determined by the phase of the investigation (an exploratory investigation usually requires a lower density sample spacing than a main investigation) and acceptable levels of uncertainty. The British Standard for the *Investigation of potentially contaminated sites* (BS 10175: BSI, 2011) states that typical densities of sampling grids can vary from 25–50 m centres, equivalent to 4–16 samples per ha, for exploratory investigations and 10–25 m centres for main investigations, equivalent to 16-100 samples per ha. However, the standard also suggests that higher density sampling of <10 m centres may be required if a higher level of confidence is required or preliminary sampling has shown heterogeneous conditions.

It is also possible to assess the sampling grid required for a given area based on a specified degree of statistical confidence. Two such methods are provided in the R&D Technical Report P5-066/TR (EA, 2001) and CLR 4 (DEFRA/EA, 1994); see references section.

In some cases, such as colliery spoil tips and ex-mineral workings, the potential for contamination will vary depending on variables such as local conditions, the ore being mined and local geology. In such examples, the sampling strategy and hence minimum number of samples to be collected will be heavily dependent on expert opinion taking account for the site-specific circumstances and, as always, ensuring the sampling strategy is able to satisfy the objectives of the investigation. Consequently, if the objectives are to test for the presence of, for example, contaminants or acid generating materials, then the sampling strategy must be appropriately conservative. Where contamination is expected, or is possible, or where heterogeneity is likely to be high (as in the example of colliery spoil) the sampling strategy should be for 'potentially contaminated land' (detailed above). If, however, the mine workings are not metalliferous or not expected to contain contaminants or acid-generating materials, etc, then there may be a strong argument to reduce the sampling frequency, e.g. to 3 sample per ha or fewer (see above). In all cases, the final decision should be made by an appropriately qualified professional. It is worth remembering that the collection of more samples than initially envisaged necessary for analysis is cost-effective. This is because a subset can be analysed to provide preliminary data, then additional samples can be analysed once the requirement for further information has been identified.

Examples on how to employ professional judgement are given in the case studies (pages 10–12) but as an absolute minimum it is recommended that for a Phase II investigation 22 samples are taken across a site where the total site area is less than 7 ha (BS 10175: 2011). For sites of an area greater than 7 ha it is recommended that the minimum of 3 samples per ha are taken. Table 2 shows the hotspot area which will have a 95% likelihood of being found based on this rule.

To reiterate, the sampling strategy must be able to satisfy the objectives of the investigation; the final decision should be made by an appropriately qualified experienced practitioner, and should be fully justified and defensible. It is worth remembering that a conceptual site model highlights the existence of potential (or plausible) pollutant linkages and that it is the presence of a *significant* pollutant linkage that categorises a site as contaminated land. Therefore, it is the objective of a site investigation to test the conceptual model and determine whether the potential pollutant linkages are significant. Consequently, the sampling strategy (sampling type and frequency) aims to fulfil this objective. If the data ultimately obtained do not fully satisfy this aim and uncertainties remain then more data must be gathered until the uncertainties are fully remedied.

Table 2 Hotspot area based on the minimum sampling guidance rule.

Site area (A) (ha)	Hotspot radius (r) (m)	Hotspot area (a) (m^2)	No. of samples (N)
0.5	8.9	250	22
1	12.6	500	22
2	17.8	1000	22
3	21.9	1500	22
5	28.2	2500	22
7	33.4	3500	22
10	33.9	3600	30
20	33.9	3600	60
30	33.9	3600	90
40	33.9	3600	120
50	33.9	3600	150
60	33.9	3600	180

Calculating optimum number of samples for locating and characterising hotspots

Sampling is an expensive and time-intensive activity which should always be based on sound professional judgement. It is imperative that sampling is conducted from knowledge ascertained in the Phase I Survey to remove uncertainty underlying judgement on identified risks and hazards. As an example, a closed colliery site can, for simplicity, be divided into two areas: the spoil tip and the working area which contains all buildings and stock yards. The latter will require much more intensive sampling than the spoil tip.

On this basis, a judgement should be made as to the risks of conducting sampling that does not adequately identify hazards which could seriously jeopardise the reclamation or significantly harm receptors. Remedying reclamation failure or receptor harm could have major financial and public relations consequences. Optimising sampling design as part of the Phase II investigations is likely to result in a reduced likelihood of having to perform (or the requirement for) subsequent sampling. Therefore, it is highly likely to be cost-effective in the long term to sample more intensively within a Phase II investigation than merely conducting sampling to the minimum requirement.

When planning sampling it is important to ascertain:

- the likely area of a hotspot;
- the likely shape of a hotspot;
- the risk of not uncovering the hotspot.

Once these have been ascertained the optimum number of sampling points (N) required to give a 95% likelihood of finding the hotspot can be calculated using:

$$N = \frac{kA}{a}$$

where:

N = number of sampling points required

A = total site area (m^2)

a = hotspot area (m^2)

k = hotspot shape constant

Table 3 shows hotspot shape constants *(k)* for a range of predicted shapes.

Table 3 Hotspot shape constants for use in calculation of *N*.

Predicted hotspot shape	Hotspot shape constant (k)
Circular	1.08
Plume shaped	1.25
Elliptical	1.80
Conservative choice where shape is unknown	1.50

Calculation of grid size

Having determined the number of sampling points to be employed, it is then useful to calculate the grid size (*D*), in order to lay out a sampling grid. Grid size is calculated using:

$$D = \sqrt{\frac{A}{N}}$$

where:

D = grid size (m)

A = total site area (m^2)

N = number of sampling points

When determining the offset required to set out a herringbone design it is recommended that the offset distance (*od*) is one quarter of the grid size (*D*).

$od = 0.25$

Discretion of field workers

Fieldworkers should be given some discretion as to where samples are taken. For example, if a sampling point is positioned over a drainage ditch a fieldworker could legitimately move the sampling point to one side of the ditch, away from the area of disturbance. It is important that the new position of the sampling point and the reason for moving it are recorded and communicated to the project manager.

Sampling depth

Sampling depth increments should be chosen based on the potential pollutant pathway or soil properties under investigation. For potentially contaminated sites, sampling depths should consider the potential source of contamination, exposure route(s) and the receptors that are likely to be affected. For example, when determining the potential risks of direct ingestion or inhalation of contaminated materials affecting human health, then sampling could be legitimately limited to the upper 0.15 m of material. If groundwater is a potential receptor of contamination, then it would be reasonable to sample material at 0.5 m intervals from the surface to the depth of groundwater.

However, sampling depths chosen should reflect the potential mixing and disturbance of the soil profile which is likely to occur as part of the restoration, e.g. through cultivation or provision for drainage. For example, if complete cultivation was used to alleviate compaction it would also result in a redistribution of contaminants and nutrients both within the soil profile and across the site. Therefore the results of surface sampling of material conducted prior to cultivation would be of limited use, for example, for assessing the potential human health risks associated with inhalation or ingestion of soil from the post-cultivated site. For guidance purposes, establishing trees requires cultivation and therefore likely disturbance of up to 1.5 m while for grassland and wildflower meadow 0.3–0.7 m is normally sufficient (nominally, cultivation is performed to 0.5 m for grassland).

Regrading the topography of a site is not uncommon. Industrial and indeed remedial activities can require moving several metres of material from one part of a site to another. If such activity is likely to form part of the restoration then sampling should take redistribution into account. Wherever practical, additional sampling should also occur at the post-cultivation and grading stage of the restoration.

Circumstances specific to the site or to the study will determine whether depth increments should be based on professional judgement, regular depths or a combination of both. At all times, decisions must be based on sound, defensible judgement for the situation being assessed, and should be recorded accordingly.

Sample analysis

Sample analysis should be planned to adequately characterise the issues being addressed by the sampling activity. For example, consideration should be given to the bioavailability of contaminants and nutrients, rather than being restricted to total soil concentrations. BPG Note 2: *Laboratory analysis of soils and spoils* deals with analytical requirements for determination prior to vegetation establishment. Advice on contaminant testing including cost of analysis should be sought prior to producing a sampling design. It is recommended that more samples are taken than initially envisaged necessary for analysis, as these can be analysed once the preliminary data have been assessed and the requirement for further information has been identified.

Samples may have a 'shelf-life', after which time they should not be analysed as the data will be unreliable, e.g. a TPH (total petroleum hydrocarbon) sample should be analysed within 14 days of sampling as degradation will have an effect on the results. This approach is less likely to result in the need for a second site visit (in order to fulfil additional sampling requirements) and thus represents, in most cases, an overall cost saving. Developers may consider analysing a subset of samples for the analytes which will give the greatest indication of contaminant behaviour. To assist selection of an appropriate subset of samples, it is helpful to consult *Industry profiles* (DETR, 1996).

Recording sampling information

The following information must be recorded when sampling is undertaken:

1. Sampling approach, i.e. targeted or non-targeted or combined.
2. Sampling design including spacing, frequency and distribution, and a site map showing sampling points.
3. Sampling depths.
4. Sample analytical requirements with justification.
5. Date and time of sampling, and name of fieldworker.
6. Sampling method, e.g. auger, digger.
7. Purpose of each sampling location.
8. Observation of material types, e.g. made-ground with reference to stone content and size, textural class, colour; observations of visually unusual material properties.

Interpreting the data from sampling

Land contamination assessment is a phased risk assessment process (as described in the context and timing section, page 1), affording multiple opportunities to exit where the Local Authority (as the responsible regulatory body) determines there to be insufficient evidence that the land might be contaminated (i.e. for land to proceed to the next stage of risk assessment there should be evidence that an unacceptable risk could reasonably exist). The process of risk assessment involves understanding the risks presented by the contaminants and the associated uncertainties. In practice, this involves quantification and testing of the conceptual model through, in the first instance, assessing the levels of contaminants present against generic assessment criteria (GAC), such as Soil Guideline Values (SGVs) – published by the Environment Agency – or the *Generic assessment criteria for human health risk assessment* (LQM/CIEH, 2009). Where there are no published assessment criteria, site-specific assessment criteria (SSAC) are derived using computer models (e.g. CLEA or SNIFFER). Use of generic or site-specific assessment criteria requires informed understanding of how and for what purpose they were derived. Analysis and interpretation should be conducted by a suitably qualified experienced practitioner.

Presentation of data analysis to the regulatory body will enable them to make their assessment according to their statutory duties and to request remedial action if required.

Health and safety considerations

A risk assessment should be made for potential risks and hazards likely to be encountered during the site intrusive investigation, as identified during Phase I investigations (i.e. desk study and site walkover) and appropriate steps taken (for example, use of personal protective equipment).

CASE STUDY 1

Former agricultural field system of 21 ha

Background No contamination risk has been identified by the Phase I desktop survey. Soil maps of the site, showing soil type, were discovered as part of the Phase I investigation. Cultivation and regrading activities are expected to be of low intensity. Figure 3 is a typical example of an agricultural field system to be assessed in this way.

Sampling objective To determine soil conditions for establishing trees and a wildflower meadow.

Proposed sampling design Targeted sampling based on professional judgement using maps of soil type.

Determining number of samples (*N*) A minimum of three samples per distinct soil type or ha (whichever is the greater).

Sampling depth Proposed woodland areas: 0–20, 40–80, 100–150 cm to correspond with the expected rooting depth of the trees. Proposed wildflower areas: 0–20, 20–40 cm to correspond with grass and wildflower rooting depth.

Sample analysis All samples analysed for organic carbon, pH, available N and P, total N. Subsample of the samples analysed for potentially toxic elements, particle size distribution, total S, cation exchange capacity (CEC).

Figure 3 Typical farm setting showing oil seed rape as a main crop. Soil analyses will consider nutrient status and presence of a plough pan.

CASE STUDY 2

Former open-cast colliery site of 34 ha

Background The area had been previously restored to grassland for sheep grazing. A low risk of metal or organic contamination had been identified by the Phase I desktop survey. Visual inspection highlighted a high risk of compaction of some areas of >10 000 m^2. Information on geological material and local knowledge of similar sites within the vicinity highlighted a medium risk of the presence of acid-generating materials. Visual assessment indicated presence of ochre in drainage seeps and ditches along the lower slope of the site boundary. Drainage ditches are considered as surface water receptors under Part IIA of the Environmental Protection Act 1990. Figure 4 shows a similar open-cast site including some reclaimed land and new planting, the fruits of successful investigation and planning.

Sampling objectives To determine soil conditions for establishing trees and a wildflower meadow. To delineate areas of compaction. To check for the presence of acid generating materials and their potential impact on ground and surface water quality.

Proposed sampling design Non-targeted using herringbone pattern with targeted sampling along the drainage line from the upper to lower slope where ochre had been observed.

Determining number of samples (*N*) A minimum of three samples per distinct soil type or ha (whichever is the greater).

Sampling depth Proposed woodland areas: 0–20, 40–80, 100–150 cm to correspond with the expected rooting depth of the trees. Proposed wildflower areas: 0–20, 20–40 cm to correspond with grass and wildflower rooting depth.

Sample analysis Soil compaction assessed for all sample locations and for each of the defined depths.

All samples analysed for organic matter content, pH, electrical conductivity, iron pyrite, total S, available N and P, total N.

Subsample of the samples analysed for potentially toxic elements, essential nutrient availability (including Ca, Mg, K, Fe and Mn), CEC, particle size distribution, stoniness and bulk density.

Figure 4 Open-cast working site displaying the variability in site conditions alongside newly planted reclaimed land in the foreground.

CASE STUDY 3

Former agricultural field of 2 ha

Background During the Phase I desktop survey it had been ascertained that sheep dipping had taken place regularly throughout the late 1960s and 70s, but no record of exact whereabouts was uncovered and no record had been made of the type of chemical used; experience has shown that the most common chemical used during that period was Diazinon. Professional experience has shown that hotspot area due to organophosphate contamination is likely to be <500 m^2. Potential receptors include human health and groundwater.

Sampling objective To delineate the area where sheep dipping had taken place.

Proposed sampling design Herringbone.

Determining number of samples (*N*)

Total site area (*A*) = 20 000 m^2

Hotspot area (*a*) = 500 m^2

It is assumed that the hotspot is circular: k = 1.08

Calculate the optimum number of samples (*N*) using:

$N = kA/a$

$N = (1.08 \times 20\,000) / 500 = 43.2$

Therefore 44 samples would have a 95% likelihood of finding the 500 m^2 hotspot.

Calculate grid size (*D*)

Grid size is determined using:

$$D = \sqrt{\frac{A}{N}}$$

$$D = \sqrt{\frac{20\,000}{44}} = 21.3$$

For ease of setting out a 21 m grid would be used.

The offset distance (*od*) required to set out as a herringbone design is one quarter of the grid size (*D*).

$od = 0.25 \times (D)$

$od = 0.25 \times 21 = 5.25$ m

Sampling depth Every 50 cm (e.g. 0–50, 50–100) from the surface to the depth of the groundwater. An example of a soil profile pit is shown in Figure 5.

Sample analysis All samples analysed for Diazinon, metabolites of Diazinon and harmful impurities of the proprietary insecticidal treatment.

Figure 5 Soil profile pit: useful for studying soil types with depth, investigating rooting depths and sampling soils for chemical analysis.

CASE STUDY 4

Land surrounding and including a former metal smelting site

High risk of metal contamination affecting human health through inhalation and ingestion from both metal ores and coal ores used in the smelter furnaces. Medium risk of organic contamination arising from fuel storage and use on site, and high sulphur content of soils from coal/coal dust.

Sampling objective To determine soil metal concentrations and nutrient conditions for establishing community woodland with access to the public and in close proximity to a surface water and site of special scientific interest (SSSI). Figure 6 shows why such sampling is important – acidic conditions have caused total tree mortality.

Proposed sampling design Combined: non-targeted, herringbone pattern for the area where the former smelter infrastructure was sited and targeted for the land surrounding the smelter.

Determining number of samples (N)

Total site area (A) = 10 ha (= 100 000 m^2)

Hotspot area (a) = 300 m^2

It is assumed that the hotspot shape is unknown: $k = 1.5$

The optimum number of samples (N) is:

$$N = kA/a$$

$$N = (1.5 \times 100\,000) / 300 = 500$$

Therefore 500 samples would have a 95% likelihood of finding a hotspot of 300 m^2 or greater.

Calculate grid size (D)

Grid size is determined using:

$$D = \sqrt{\frac{A}{N}}$$

$$D = 14.14$$

For ease of setting out a **14 m** grid would be used, and an offset distance *(od)* of **3.5 m** would be required to set out a herringbone design.

Sampling depth Proposed woodland areas: 0–20, 40–80, 100–150, 150–200 cm to correspond with the expected rooting depth of the trees. In comparison to Case study 2, an extra depth of investigation at 150–200 cm is also sampled to test for contaminant mobility and risk to groundwater.

Proposed wildflower areas: 0–20, 20–40 cm to correspond with grass and wildflower rooting depth.

Sample analysis Soil compaction assessed for all sample locations and for each of the defined depths, together with soil type/particle size distribution, stoniness and bulk density and organic matter content.

All samples analysed for potentially toxic elements including Pb, Zn, Cu, Cd, As, Ni and Hg. As well as total concentrations, contaminant mobility and bioavailability assessed through leachate tests, pH and cation exchange capacity (CEC).

Subsample of the samples analysed for electrical conductivity, total S, available N and P, total N, plus Ca, Mg, K, Fe and Mn.

Figure 6 Seven-year-old tree planting on an acidic colliery spoil in the West Midlands, England, showing total mortality.

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Useful links

Details of Contaminated Land and Contaminated Land Legislation can be found on the Defra website.

Details of the UK SGVs can be found on the EA website.

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The Land Regeneration and Urban Greenspace Research Group
Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH
Phone: +44 (0) 1420 22255 Fax: +44 (0) 1420 520180
www.forestry.gov.uk/forestresearch