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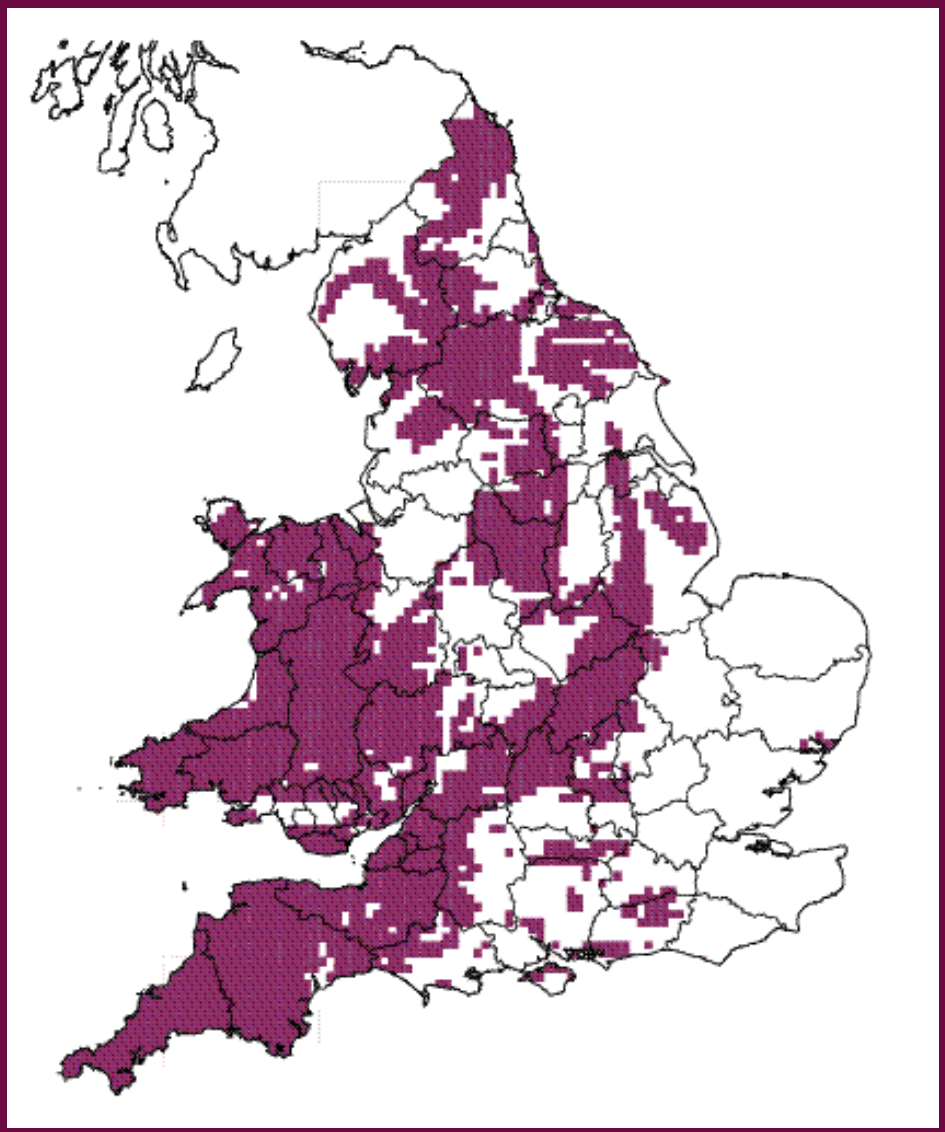
Dealing with radon emissions in respect of new development

Summary report and recommended framework for planning guidance



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NATURAL ENVIRONMENT RESEARCH COUNCIL

BRITISH GEOLOGICAL SURVEY

RESEARCH REPORT RR/00/07

Dealing with radon emissions in respect of new development

Summary report and recommended framework for planning guidance

J D Appleton
British Geological Survey
J C H Miles
National Radiological Protection Board
C R Scivyer
Building Research Establishment
P H Smith
Land Use Consultants

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Subject index
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Cover illustration
Recommended radon planning constraints map of England and Wales (derived from Maps 1 and 2, BR211 (1999).

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British Geological Survey Offices

Keyworth, Nottingham NG12 5GG
☎ 0115–936 3100 Fax 0115–936 3200
e-mail: sales @bgs.ac.uk
www.bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA
☎ 0131–667 1000 Fax 0131–668 2683

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE
☎ 020–7589 4090 Fax 020–7584 8270
☎ 020–7942 5344/45

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU
☎ 01392–445271 Fax 01392–445371

Geological Survey of Northern Ireland, 20 College Gardens, Belfast BT9 6BS
☎ 01232–666595 Fax 01232–662835

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB
☎ 01491–838800 Fax 01491–692345

Parent Body

Natural Environment Research Council
Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU
☎ 01793–411500 Fax 01793–411501

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DETR Steering Group

Mr F J Atkins (NHBC)
Dr A J Burke (BRD-DETR)
Mr T J Gregory (Cornwall County Council/Association of County Councils)
Mr J T Hague (Local Government Associations)
Mr G A Hudd (Somerset County Council)
Mr M Johnson (BRD-DETR)
Mr M Jones (Association of District Councils)
Dr A J Macpherson (RAS-DETR)
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Mr B W T Spiers (Scottish Executive)
Prof. I Thornton (Centre for Environmental Technology, Imperial College of Science, Technology and Medicine)
Mr D W Tuffin (The Royal Institution of Chartered Surveyors)
Mr P Watson (County Planning Officer's Society)
Mr P Watts (The Royal Town Planning Institute)

Executive summary

INTRODUCTION

In the early 1990s, administrative and policy responses to radon problems in new development had limitations in that:

— new development was not adequately covered by existing responses in radon-prone areas which had not been designated as radon Affected Areas.

— the mapping procedures used to identify those areas where protective measures were required in new dwellings in some cases resulted in radon protection not being installed where required, and vice versa.

— material change of use or non-domestic development, including workplaces and certain residential institutions, was not adequately dealt with.

— procedures were not in place to ensure that developers were made aware of requirements for protective measures in new dwellings or of employers'responsibilities with regard to radon under the *Health and Safety at Work etc. Act 1974* and *Ionising Radiations Regulations 1985* at the planning or pre-planning stage.

— developers and future occupiers of buildings subject to material change of use (for example from agricultural or workplace to domestic use (e.g. barn conversions)) but not subject to Requirement C2 of Schedule 1 of Building Regulations 1991 were not necessarily made aware of the possible need for protective or remedial measures.

These limitations have been addressed by the Department of the Environment, Transport and the Regions (DETR) research programme 'Dealing with radon emissions in respect of new development'which aimed to identify the circumstances, if any, where new development may be adversely affected by radon emissions and the appropriate response to such problems. Fulfilment of these objectives will help to ensure that occupiers of new domestic and non-domestic developments will be adequately protected against the harmful affects of radon. The research programme was carried out by the British Geological Survey (BGS) working in collaboration with the Building Research Establishment Ltd. (BRE), Land Use Consultants (LUC) and the National Radiological Protection Board (NRPB)

This report describes administrative responsibilities and policy responses; summarises how radon in new development is dealt with through the building control system; describes a potential planning response that may deal with some of the perceived limitations in the current response through building control; and provides a recommended framework for guidance for building control, planning and environmental health.

ADMINISTRATIVE RESPONSIBILITIES AND POLICY RESPONSES

England and Wales

Responsibility for dealing with the radon issue is shared by the Department of the Environment, Transport and the Regions (DETR), the Health and Safety Commission (HSC), and the NRPB (which is sponsored by the Department of Health). The National Assembly of Wales has responsibility for radon policy for existing dwellings in Wales. BRE provides technical guidance on protective and remedial measures. Local Authority building control officers and Approved Inspectors enforce regulations and guidance for dealing with radon in new development through the Building Regulations. The Health and Safety Commission is responsible for defining standards, through the *Ionising Radiations Regulations 1999* and any future legislation, that need to apply in workplaces. The Commission is also responsible for issuing guidance and enforcing the regulations. This is done through the Health and Safety Executive (HSE) and Local Authority Environmental Health Departments. The BGS researches the geological controls on radon.

Responses in other countries

Eight other European countries (Czech Republic, Denmark, Finland, Ireland, Latvia, Norway, Slovak Republic and Sweden) have regulations and guidelines for construction requirements to prevent elevated radon concentrations in new buildings. Austria, Germany, Greece and Switzerland plan to introduce such regulations. In most of the countries with regulations, enforced radon protection in new buildings is specified in the national Building Codes. Implementation of regulations is normally shared by National and Local authorities. Seven European countries (Czech Republic, Denmark, Finland, Ireland, Norway, Slovak Republic and Sweden) have regulations and guidelines for radon prevention in the planning stages of new

development (e.g. where construction permits are applied for dwellings, offices and factories). Austria and Germany are considering the introduction of guidance and/or regulations for dealing with radon at the planning stage. In the Czech Republic, Ireland, Slovak Republic and Sweden, regulations require an investigation of radon risk at construction sites before building is permitted.

In Canada, radon is considered to be a minor regional problem and is dealt with at the construction stage as part of local building codes. In the USA, the indoor radon strategy is implemented by the US Environmental Protection Agency (EPA) and involves national and regional surveys, health studies, geological mapping and characterisation studies, land evaluation activities, mitigation and prevention activities, and issuing health guidelines. There are no federal requirements for the construction of new buildings in the USA. Each local authority area has its own version of the Building Code in which radon is treated like any other building problem. Most of the US does not have mandatory regulations or guidelines.

BUILDING CONTROL AND BUILDING REGULATIONS

New dwellings

Statutory requirements relating to radon are contained in Requirement C2 of Schedule 1 of the Building Regulations 1991 for England and Wales which states: 'Precautions shall be taken to avoid danger to health and safety caused by substances found on or in the ground to be covered by the building'. The Approved Document refers to BRE Report, BR211, *Radon: Guidance on protective measures for new dwellings*, for detailed guidance on where such protection is necessary and practical construction details. The guidance in the Approved Document is limited to new dwellings and extensions but the requirement applies to all buildings.

Identification of development sites where radon protection required in new dwellings

Potential options for targeting radon protective measures in new dwellings and extensions to dwellings through the Building Control system include:

BC-1: Universal application of radon protective measures.

BC-2: Mapping defines need for protective measures.

BC-3: Mapping defines need for protective measures. Site investigation may be used to permit relaxation of regulation if the developer wishes to use this option.

BC-4: Universal site investigation defines the need for protective measures.

Whereas it might be considered that Option BC-1 would involve unnecessary expenditure in much of England and Wales, blanket installation of a radon barrier would actually involve minimal additional cost to new dwellings (about £50–100) and would result in benefits to the development other than radon protection. Although cost is a consideration in the assessment of regulatory proposals, it is not the deciding factor.

Options BC-2 and BC-3 both require maps that can be readily used by Building control bodies, developers and others concerned with radon protective measures. Recommendations for the production of a radon potential map for use by building control and planning systems evolved out of a study of the relative advantages and disadvantages of using grid square radon potential mapping and geological radon potential mapping to designate areas where radon protective measures are required. It was concluded that geological radon potential mapping in general provides the best spatial detail and accuracy as this method relates radon risk to geology — identified as the most important overall control on the concentration of radon in dwellings. A geological radon potential mapping exercise for England and Wales was carried out as part of this research programme using the BGS 1:250 000 scale lithostratigraphic (bed rock) and the 1:625 000 scale drift digital map data. Combinations of bed-rock and drift (unconsolidated deposits) with geological radon potentials considered to require protection were mapped and converted into a 5 km grid map for publication in the revised version of BR211 (1999). The 5 km grid maps were upgraded to take into consideration more detailed 1:50 000 scale maps covering some of the most radon-prone areas of England.

The results of this research programme indicate that in most cases it is impractical to assess the severity of a radon problem on a particular site accurately until the building has been constructed and occupied, therefore precautions should be taken in areas where high radon levels have been predicted by the mapping programme. Radon site investigation techniques are not yet reliable or cost-effective enough to be incorporated into guidance.

A requirement for a radon site investigation to be carried out on all new development sites (Option BC-4), as is currently required in Sweden, for example, would lead to unnecessary expenditure for both developers and Building Control authorities.

Revised Guidance (BR211, 1999)

Amendments to the guidance document (BR211) published in November 1999 reflect greater knowledge of radon-prone areas and the advances made in developing practical cost-effective protective measures. The DETR Building Regulations Division devised a system for determining the level of protection needed based on two sets of maps that show, as 5 km grid squares of the National Grid used by the Ordnance Survey, where radon protective measures are indicated and whether a geological assessment might allow a lower level of protection.

Radon protection in new workplace buildings

Although there is a gap within guidance to support the Building Regulations regarding radon protection for workplace buildings, there are a number of reasons that make it difficult to develop similar guidance to that developed for dwellings:

— there is a far wider variation in construction types used, as well as in the size and use of buildings than with dwellings, which make it difficult to offer precise guidance.

— identification of those areas where protective measures in new workplaces should be installed would be difficult using grid square or geological radon potential mapping.

A prudent developer, especially in an area where radon emissions are high, should consider the possibility that radon levels inside the building may be high enough to require protective measures and to provide them at initial construction. This is particularly important for new multi-purpose work place developments.

RADON AND THE PLANNING SYSTEM

Radon as a material planning consideration

Since radon emissions in new development can pose a risk to people's health, they may be a material planning consideration. It follows, therefore, that local planning authorities should have regard where necessary to the issue of radon emissions in preparing development plans and deciding on planning applications, the aim being to ensure that radon protective or remedial measures are incorporated, where appropriate.

Potential Planning Response

Radon is not mentioned in current planning legislation or planning policy guidance issued by the Government. None of the planning authorities in areas with high radon that have adopted or approved development plans has a policy relating to radon. There are no circumstances where the problem of radon emissions in new development cannot be overcome through appropriate protective or remedial measures. It would therefore be inappropriate for planning permission to be refused solely because of the presence of potentially harmful radon concentrations.

Response to planning consultation

Consultation with representatives of the planning profession regarding the potential role of the planning system in dealing with radon in new development identified the following main issues:

(i) Most planners consulted agree that whereas the planning system should address the problem of radon emissions in new development, the role of the planning system should be confined to the provision of information about the problem and how it can be overcome.

(ii) Maps in BR211 (1999) could be used to produce planning 'constraints maps'. These would indicate those areas where informatives need to be attached to planning decision notices for new development and changes of use.

(iii) The planning system should not be used as a means of ensuring that the appropriate Building Regulations and Health and Safety Legislation are effectively enforced. A simple informative attached to planning permissions would meet any perceived duty of local authorities to inform of potential hazards in those cases where it isn't covered by current legislation and would do no harm in cases which are covered.

RECOMMENDED FRAMEWORK FOR GUIDANCE

Introduction

There are four main categories of new development or changes to use of land in radon-prone areas which may result in people being exposed to radon emissions. These are:

Category 1 — new dwellings or extensions to dwellings; material alteration to dwellings or conversion to domestic use;

Category 2 — new workplaces or residential institutions or material changes to workplace use;

Category 3 — change from workplace to domestic use not involving material alteration/conversion;

Category 4 — change from domestic to workplace or non-domestic residential use not involving material alteration or conversion.

The following recommendations provide a framework for dealing with radon in these categories of new development through Planning, Building Control, Health & Safety and Environmental Health systems.

Planning

The role of the planning system should be confined to the provision of information about the problem of radon emissions in new development and how it can be overcome (i.e. through the application of relevant Building Regulations and Health and Safety Legislation and the provision of information about relevant guidance). The information should be contained in development plans and in decision letters about individual planning applications.

It is recommended that the radon issue should be addressed as part of the current revision of PPG 23 on *Planning and Pollution Control (Contaminated Land)* and the Technical Advice Note (TAN) on *Planning, Pollution Control and Waste Management* in Wales.

A system based on planning informatives may be the most practical option for ensuring that radon protection is adequately dealt with in cases of material change of use (such as barn conversions) or non-domestic development, including workplaces and certain residential institutions.

This potential planning response appears to deal effectively with the last three of the limitations of current responses (see Introduction above).

Building Control

Statutory requirements relating to radon are contained in Requirement C2 of Schedule 1 of the Building Regulations 1991 for England and Wales. BRE Report, BR211, *Radon: Guidance on protective measures for new dwellings*, provides detailed guidance on where such protection is necessary and practical construction details. The guidance in the Approved Document is limited to new dwellings and extensions but the requirement applies to all buildings. Whereas buildings other than dwellings are subject to Requirement C2 of the Building Regulations, this could be made clearer if a paragraph on non-domestic building was added to the Approved Document to Part C. Additional guidance is available for workplaces (BR293) and for remedial measures in existing dwellings (BR227 and BR250).

The maps and plates in BR211 (1999) provide information on the location of those areas where radon protective measures are required in new dwellings and extensions to dwellings (*Category 1* above). These maps could also be used to indicate where it may be advisable to install protective measures in *Category 2* developments and where it may be advisable to monitor for radon in *Category 3 and 4* developments, in order to verify whether remedial measures are required.

Health & Safety and Environmental Health

Regulations and guidance designed to protect the health and safety of employees and others who have access to workplaces are enforced by the HSE and Local Authority Environmental Health Departments (LAEHD). Employers occupying *Category 2 and 4* developments in radon-prone areas for the first time would be responsible for carrying out a suitable and sufficient radon risk assessment.

Scotland and Northern Ireland

Whereas this report is directed towards dealing with radon emissions in new development in England and Wales, many aspects of the framework for guidance would also be applicable, in principle, to new development in Scotland and Northern Ireland.

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TABLE

1 Introduction

1.1 Radon is a naturally occurring radioactive gas. It decays to form radioactive particles that can enter the body by inhalation. Inhalation of the short-lived decay products of radon has been linked to an increase in the risk of developing cancers of the respiratory tract, especially of the lungs, and is considered to cause approximately 5% of deaths from lung cancer in the UK. In order to limit the risk to individuals, the Government has adopted an Action Level for radon in dwellings of 200 becquerels per cubic metre (Bq m^{-3}). The Government advises householders that, where the radon level exceeds the Action Level, measures should be taken to reduce the concentration.

1.2 Radon gas comes from uranium that occurs naturally in the ground. The production of radon from rock and overburden, including glacial and fluvial deposits and soil, is affected primarily by the amount of uranium within the rock-forming minerals and their weathering products. The variation in radon levels between different parts of the country is mainly controlled by the underlying geology. Most radon remains in rocks and soils. However, once released from minerals, it can migrate through bedrock and soils and accumulate in buildings.

1.3 Radon enters a building primarily by airflow from the underlying ground. The key routes by which radon enters buildings are through cracks in solid floors or walls below ground level, through construction joints and cavities in walls, or through gaps in suspended concrete or timber floors or gaps around service pipes. In addition, the heating and ventilation systems, and life style of the house occupants are important factors affecting radon accumulation in buildings.

1.4 In radon affected homes, the problem of radon can usually be tackled with simple, effective and relatively inexpensive measures, which are comparable in cost to work such as damp-proofing and timber treatment. The cost of installing radon protective measures in new dwellings is relatively low (£50–150 per dwelling) in comparison with the direct and indirect costs associated with treating lung cancer.

1.5 In the early 1990s, administrative and policy responses to radon problems in new development had limitations in that:

- new development was not adequately covered by existing responses in radon-prone areas which had not been designated as radon Affected Areas.
- the mapping procedures used to identify those areas where protective measures were required in new dwellings in some cases resulted in radon protection not being installed where required, and vice versa.
- they did not adequately cover material change of use or non-domestic development, including workplaces and certain residential institutions
- procedures were not in place to ensure that developers were made aware of requirements for protective measures in new dwellings or of employers'responsibilities with regard to radon under the *Health and Safety at Work etc. Act 1974* and *Ionising Radiations Regulations 1985* at the planning or pre-planning stage
- developers and future occupiers of buildings subject to material change of use (for example from agricultural or workplace to domestic use (e.g. barn conversions)) but not subject to Requirement C2 of Schedule 1 of Building Regulations 1991 were not necessarily made aware of the possible need for protective or remedial measures.

1.6 These limitations have been addressed by the Department of the Environment, Transport and the Regions (DETR) research programme 'Dealing with radon emissions in respect of new development' which aimed to identify the circumstances, if any, where new development may be adversely affected by radon emissions and the appropriate response to such problems.

The objectives of the research were:

a) to identify the circumstances where new development or changes to land use may result in people being exposed to radon emissions which are prejudicial to health or are above the 'Action Level';

b) to consider what information is required to enable such radon risks to be assessed and precautions to be targeted more effectively and how this should be collected, collated and presented;

c) to examine what options, including preventive and remedial measures, are available to prevent adverse accumulations of radon within new development; and

d) to present results in forms suitable for both specialists and non-specialists in issues associated with radon.

1.7 Fulfilment of these objectives will help to ensure that occupiers of new domestic and non-domestic developments will be adequately protected against the harmful affects of radon.

1.8 The research programme, carried out by the British Geological Survey (BGS) working in collaboration with the Building Research Establishment Ltd. (BRE), Land Use Consultants (LUC) and the National Radiological Protection Board (NRPB), started in December 1995. The consultation exercise and subsequent revision of the Guidance Document BR211 *Radon: guidance on protective measures in new dwellings* delayed execution of the project. This process extended the research programme from February 1997 until publication of the revised guidance in November 1999.

1.9 The purpose of this report is to explain the background to dealing with radon in new development; highlight where improvements to the responses could be made; identify the available options for dealing with radon in new development including their relative advantages and disadvantages; identify the potential role of the planning system; and finally to present conclusions and recommendations on which option(s) would be most appropriate and effective for ensuring that new development is protected against radon emissions.

1.10 The report has a further four sections following this introduction:

Section 2 describes administrative responsibilities and policy responses.

Section 3 summarises how radon in new development is dealt with through the building control system.

Section 4 describes a potential planning response that may deal with some of the perceived limitations in the current response through building control.

Section 5 provides a recommended framework for guidance for building control, planning and environmental health.

2 Administrative responsibilities and policy responses

England and Wales

2.1 Responsibility for dealing with the radon issue is shared by the Department of the Environment, Transport and the Regions (DETR), the Health and Safety Commission (HSC), and the NRPB (which is sponsored by the Department of Health). The National Assembly of Wales has responsibility for radon policy for existing dwellings in Wales.

2.2 The DETR Radioactive Substances Division is responsible for radon policy in England and the National Assembly for Wales has responsibility for radon policy in Wales. The DETR Building Regulations Division is responsible for Regulations and guidance relating to radon protection in new buildings in England and Wales. The NRPB advises, researches, and provides technical services regarding protection against ionising and non-ionising radiations. To this end it is currently monitoring radon in homes and workplaces and delineating Affected Areas. The NRPB has found that the average level of radon in dwellings in Britain is about 20 Bq m^{-3}. Based on the estimated risks of lung cancer from prolonged exposure, the NRPB has recommended, and the Government has accepted, an *Action Level* for radon in homes of 200 Bq m^{-3}. If the annual average radon level in a home exceeds this value, householders are advised to take action to reduce it.

2.3 The NRPB has recommended that parts of Britain with 1% probability or more of homes being above the Action Level should be designated as *Radon Affected Areas*. These areas are designated by the NRPB by mapping levels of radon in existing homes. Other areas, referred to in this report as radon-prone, are known to have the potential for radon problems but they have not yet been designated as Radon Affected Areas. The BGS researches the geological controls on radon and provides geological radon potential maps for the DETR for use in identifying with greater precision the location of homes likely to be above the Action Level and to inform future radon measurement campaigns.

2.4 Provision has been made in *Requirement C2 of Schedule 1 of the Building Regulations 1991* for the protection of new buildings against the ingress of radon. BRE provides technical guidance on protective and remedial measures. Local Authority building control officers and Approved Inspectors enforce regulations and guidance for dealing with radon in new development through the Building Regulations.

2.5 The Health and Safety Commission is responsible for defining standards, through the Ionising Radiations Regulations 1999 and any future legislation, that need to apply in workplaces. The Commission is also responsible for issuing guidance and enforcing the regulations. This is done through the Health and Safety Executive (HSE) and Local Authority Environmental Health Departments.

2.6 Under the *Health and Safety at Work etc. Act 1974* (HSW Act), employers must ensure the health and safety of employees and others who have access to that working environment. Protection from exposure to radon at work is specified in the *Ionising Radiations Regulations 1999* made under the HSWAct. The concentration at which measures should be taken in work places, based on the *Ionising Radiations Regulations 1999* and the associated *Approved Code of Practice — Part 3 Exposure to radon* (HMSO, 1988), is 400 Bq m^{-3}.

2.7 Radon is not mentioned in current planning legislation or planning policy guidance issued by the Government. None of the planning authorities in areas with high radon which have adopted or approved development plans has a policy relating to radon, although Cornwall and Derbyshire County Councils include information on the radon issue in their draft structure plans.

2.8 On the basis of a preliminary consultation exercise with representatives of the planning profession carried out in January 1996, it became evident that the principal reasons for the lack of coverage of radon in development plans were:

- the issue is considered to be of relatively minor importance and can be dealt with inexpensively through installation of protective measures under Building Regulations;
- there are inadequate data upon which to base an enforceable policy (i.e. the level of risk varies significantly between different parts of an authority's area);
- there is a danger of 'blighting'land without justification.

Responses in other European countries

Introduction

2.9 Eight other European countries (Czech Republic, Denmark, Finland, Ireland, Latvia, Norway, Slovak Republic and Sweden) have regulations and guidelines for construction requirements to prevent elevated radon concentrations in new buildings. Austria, Germany, Greece and Switzerland plan to introduce such regulations. In most of the countries with regulations, enforced radon protection in new buildings is specified in the national Building Codes. Implementation of regulations is normally shared by National and Local authorities (Åkerblom, 1999).

2.10 Seven European countries (Czech Republic, Denmark, Finland, Ireland, Norway, Slovak Republic and Sweden) have regulations and guidelines for radon prevention in the planning stages of new development (e.g. where construction permits are applied for dwellings, offices and factories). Austria and Germany are considering the introduction of guidance and/or regulations for dealing with radon at the planning stage. In the Czech Republic, Ireland, Slovak Republic and Sweden, regulations require an investigation of radon risk at construction sites before building is permitted (Åkerblom, 1999).

Czech Republic

2.11 The radon programme in the Czech Republic is legislatively supported by the (i) Governmental Decree No. 538, (ii) Law No. 18/1997 Coll., on Peaceful Utilisation of Nuclear Energy and Ionising Radiation and (iii) Regulation of the SÚJB (State Office for Nuclear Safety) No. 184/1997 Coll., on Radiation Protection Requirements. Radon protective measures must be implemented when a building is not located in a low radon risk area. All new development sites in the Czech Republic require, under Building Regulations, a site investigation comprising a geological survey and measurement of radon in soil gas (Barnet, 1994; Matolín, 1996). Radon concentrations in dwellings are generally proportional to concentrations in soil gas (Neznal et al., 1994; Barnet and Mikšová, 1999).

Sweden, Norway and Finland

2.12 The radon strategy in Sweden is similar in many respects to that developed in England and Wales. It is based on the measurement of radon in existing dwellings in parallel with the requirement for installation of appropriate protective measures in new dwellings. The Swedish Radiation Protection Institute (SSI) has overall responsibility for radon in dwellings including measurement techniques and judgement of risks. The National Board of Health and Welfare is responsible for setting 'limits'for existing houses and the National Housing Board sets limits for new houses (Snihs, 1992).

2.13 The Swedish Planning and Building Act (1987) requires every municipal authority to draw up plans for land utilisation which include details of matters that may affect land owners (Planning and Building Act 1:3, 1:4). The scale of these plans is usually 1:50 000 or more. Chapter 2 of the act states 'Built up areas shall be located on land which is suitable with regards to the health of the residents'. The chapter specifically mentions radon, requiring radon risk maps to be included in municipal plans.

2.14 Radon risk mapping based on results from long term monitoring in dwellings has highlighted high and low risk areas. The maps are used to determine whether radon protection is required in new buildings. Further to this, and in contrast to the policy in England and Wales, the Swedish National Board of Housing, Building and Planning has adopted a ground classification based on geology, permeability and soil gas radon measurement. This procedure is used to achieve a greater accuracy in predicting radon emissions expected on a particular construction site. Local building boards are responsible for deciding which protective measures should be installed according to radon risk determined from site investigations. In normal situations, when the concentration of radon in soil air is 10000 to 50 000 Bq m^{-3} the house has to have a radon protective construction whereas when the concentration is higher than 50 000 Bq m^{-3}, a radon safe construction has to be used. Below 10 000 Bq m^{-3} no radon protection is required although open penetrations to the ground below the house have to be sealed. Abuilding licence is granted only when the local authority is satisfied that the risk for radon has been considered and appropriate protective measures used to ensure that the radon level in the new house does not exceed 70 Bq m^{-3}.

2.15 Whereas site investigations at the planning stage of construction work provide information of direct relevance to radon protection requirements, they are relatively expensive. In addition, scientific analysis has shown that radon (and other soil gas) measurements taken from boreholes may give inaccurate results. When the soil is disturbed by bore holes the emanation rate is changed and strong lateral and vertical variations in soil properties means that there is a need for many boreholes across the site in order to obtain an accurate estimate of soil gas radon concentrations (C. Samuelsson, personal communication). Measurement of radon in the ground is carried out by municipal authorities and also by private companies. The SSI is responsible for calibration of equipment (Snihs, 1992).

2.16 The Swedish Council for Building Research has prepared guidance on protecting new buildings. It should be noted, however, that house construction in Sweden differs in many ways from that in England and Wales. Basement construction and the use of mechanical heating and ventilation systems are more common in Sweden.

2.17 Whilst planning procedures in Sweden require soil gas investigation, planning approval is rarely (if ever) rejected due to high risk from radon gas levels and gamma radiation. However, there appears to be an underlying policy to restrict building in high-risk areas.

2.l8 In Sweden, the future owner is responsible for ensuring that radon in a building does not exceed 200 Bq m^{-3}. Buildings regulations for radon protection have the legal status of Functional Requirement and stipulate that the radon concentration in a room where people stay longer than just temporarily shall not exceed 200 Bq m^{-3} (Åkerblom, 1999).

2.19 The Radiation Protection Institutes in Finland and Norway basically follow the same policy as in Sweden (Nordic Radiation Protection Institutes, 1986).

Switzerland

2.20 In Switzerland, it is a legal requirement that houses with radon levels in excess of 1000 Bq m^{-3} must have remedial action taken. As a consequence there is a need to ensure that new buildings incorporate protective measures. Research is currently underway to develop appropriate guidance for protecting new buildings. At present radon is not considered to be a planning issue.

Responses in Non-European countries

Canada

2.21 In Canada, much of the early development of the current radon policy responses was carried out principally to deal with radon problems in and around uranium mining areas. Radon is now considered to be a minor regional problem and is dealt with at the construction stage as part of local building codes. Guidance on protective measures for new buildings is offered by the Canada Mortgage and Housing Corporation which advises developers to contact the Department of Health and Welfare in Ottawa or local authority building control for advice on areas where radon protective measures should be installed.

USA

2.22 In the USA, the main objective of the Indoor Radon Abatement Act 1988 was to set a target for reducing indoor radon levels down to background levels. The Act allows individual states and local authorities to run their own radon programmes.

2.23 The indoor radon strategy is implemented by the US Environmental Protection Agency (EPA) and involves national and regional surveys, health studies, geological mapping and characterisation studies, land evaluation activities, mitigation and prevention activities, and issuing health guidelines[1]. Radon is recognised by policymakers, as one of the country's most serious environmental health issues. The EPA Map of Radon Zones assigns each of 3141 counties across the US to one of three radon zones based on radon potential (USGS, 1992). The zones have predicted average indoor screening level of >148 Bq m^{-3} (Zone 1), 74–148 Bq m^{-3} (Zone 2) and <74 Bq m^{-3} (Zone 3). Five factors were used to determine radon potential: indoor radon measurements, geology, aerial radioactivity, soil permeability and foundation type. Additional booklets for each individual state are intended to be used by local authorities in developing local protocols for dealing with radon.

2.24 There are no federal requirements for the construction of new buildings in the USA. There are, however, model standards of construction which each State and local authority can use and interpret locally to suit their particular circumstances. As a consequence each local authority area has its own version of the Building Code in which radon is treated like any other building problem. The EPA has prepared a series of guidance papers featuring model standards and techniques for the control of radon in new buildings (EPA, 1994). Few states have a co-ordinated new-build policy with regard to radon and approaches can vary dramatically from State to State, between counties and even between districts within counties. Some states, notably Florida and Washington States have drafted Model standards and techniques for the control of radon in new buildings. Few areas carry out monitoring of completed houses, even where it forms a requirement within the Building Code.

2.25 Whereas 3 of the 50 states, as well as 40 counties, cities and towns in the US have regulations mandated by law, most of the US does not have mandatory regulations or guidelines (Åkerblom, 1999).

Further background information

2.26 Further background information on radon can be obtained from the publications listed in Appendix I.

[1] Details available at *http://www.epa.gov/iaq/radon/*

3 Building control and building regulations

Introduction

3.1 Building control is separate from, but complementary to, the planning system. Its purpose is to ensure that, for certain types of development where the Building Regulations apply, the detailed design of buildings will ensure that the completed building provides a healthy and safe environment for people in and around it. The Government wishes to ensure that building control, or any other form of regulation, does not duplicate the function of the planning system (PPG1, para. 35) and vice versa.

Building Control and Building Regulations: new dwellings

3.2 The purpose of the Building Regulations 1991 is to secure the health and safety of people in and around buildings. Building Regulations are mandatory, but cast in a functional form. They are supported by Approved Documents, which are not mandatory but give guidance as to how the Building Regulations may be met.

3.3 Statutory requirements relating to radon are contained in Requirement C2 of Schedule 1 of the Building Regulations 1991 for England and Wales[2] which states: 'Precautions shall be taken to avoid danger to health and safety caused by substances found on or in the ground to be covered by the building'. The Approved Document[3] refers to BRE Report, BR211, *Radon: Guidance on protective measures for new dwellings*, for detailed guidance on where such protection is necessary and practical construction details. The guidance in the Approved Document is limited to new dwellings and extensions but the requirement applies to all buildings.

3.4 In early editions of the guidance (BR211, 1991, as revised 1992) the results of radiological surveys of radon in existing houses were used to identify those areas where precautionary measures were required[4]. These were listed by civil parish but were based upon data supplied to BRE by the NRPB in the form of 5 km grid square radon potential maps (Miles et al., 1990, 1992)[5]. Guidance in BR211 (1991, as revised 1992) advised that one of two levels of protective measures should be incorporated, dependent upon the likely severity of the radon problem:

- *secondary measures* (provision for future sub-floor extraction) based on NRPB reports showing areas where it was estimated that 3–10% of existing dwellings exceed 200 Bq m^{-3};
- *full radon protection* (installation of a radon barrier and a provision for future sub-floor extraction) based on NRPB reports showing areas where it was estimated that >10% of existing dwellings have radon levels exceeding 200 Bq m^{-3}.

3.5 Clause 3 of BR211 (as revised 1992) stated: '*within the areas listed, any site on which there is little or no possibility of an enhanced level of radon will obviously need no precautionary measures; for instance the subsoil may be such as to prevent the passage of radon or may be permanently saturated.*'

3.6 Supplementary guidance on using geology to assess indoor radon risk in new dwellings was issued as an information sheet in January 1996. It outlined how applicants seeking building approval within Derbyshire, Somerset and Northamptonshire could use geological data to demonstrate the application of Clause 3. It relied upon the applicant providing the Building Regulations approving body with the results of a site assessment comprising: desk study, ground investigation; and an assessment of risk.

3.7 Complementary supplementary guidance could have been, but was not, adopted for providing protective measures in additional geologically defined radon-prone areas that were not included within the scope of BR211 (as revised 1992).

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2 Department of the Environment and the Welsh Office. The Building Regulations 1991. Statutory Instrument 1991 No 2768. London, HMSO, 1991.

3 Department of the Environment and the Welsh Office. *Building Regulations (England and Wales)* 1991, Approved Document C, *Site preparation and resistance to moisture*, London, HMSO (1992 edition, amended.)

4 Figures 3(a), (b) and (c), Amendments to BR211 (December 1992)

5 Radon potential maps indicate the variation in probability that existing dwellings will exceed a radon reference level, which in the UK is the Action Level (200Bq m^{-3}). Grid square radon potential maps, of the type produced by the NRPB, are based on the measurement of radon concentrations in existing dwellings.

3.8 BR211 (as revised 1992) only applied to the five counties of England and Wales that were declared radon Affected Areas in 1991. The more recently published BGS 1:625 000 scale map of radon potential based on solid geology for the whole of Great Britain (Appleton and Ball, 1995) and 1:250 000 scale maps of selected areas, together with the NRPB 5 km grid square maps of indoor radon in England and Wales (Lomas et al., 1996, 1998), indicate that elevated radon levels are widely distributed in England and Wales, albeit in many cases confined to relatively small areas.

3.9 With this in mind there was a need to consider how the BR211 (as revised 1992) guidance might be revised to include the new areas and what building control procedures would provide the most effective means of dealing with radon in new development. There was clearly a need for guidance in the new areas.

Identification of development sites where radon protection might be required in new dwellings

3.10 Potential options for targeting radon protective measures in new dwellings and extensions to dwellings through the Building Control system were identified:

BC-1 Universal application of radon protective measures.

BC-2 Mapping defines need for protective measures.

BC-3 Mapping defines need for protective measures. Site investigation may be used to permit relaxation of regulation if the developer wishes to use this option.

BC-4 Universal site investigation defines the need for protective measures.

3.11 Whereas it might be considered that Option BC-1 would involve unnecessary expenditure in much of England and Wales, blanket installation of a radon barrier would actually involve minimal additional cost to new dwellings (about £50–100) and would result in benefits to the development other than radon protection. Indeed, it may be considered good building practice, as it would provide enhanced protection against the entry of moisture and other types of gases (such as carbon dioxide and methane) into the dwelling. The radon barrier may not, however, provide adequate protection in methane-prone areas, for example if there are aggressive ground conditions, a risk of excessive ground movement or an extreme gassing regime (see BR212 *Construction of new buildings on gas-contaminated land*. BRE, 1991b). Universal application of radon protective measures would assist in securing the health of people in new buildings and at the same time reduce the risk of blight and undue personal anxiety. It should be noted, however, that although cost is a consideration in the assessment of regulatory proposals, it is not the deciding factor.

3.12 Options BC-2 and BC-3 both require maps that can be readily used by Building control bodies, developers and others concerned with radon protective measures. Practical options currently available for identifying areas or sites where new development requires protection include (a) NRPB grid square radon potential maps, (b) geological radon potential maps, (c) a combination of NRPB grid square and geological radon potential maps and (d) site investigation. A detailed evaluation was carried out of the relative advantages and disadvantages of using grid square radon potential mapping and geological radon potential mapping[6] to designate areas where radon protective measures are required. Recommendations for the production of a radon potential map for use by building control and planning systems have evolved from an evaluation of mapping options in areas with many house radon measurements (Derbyshire and Northamptonshire) and also in selected areas with relatively few house radon measurements[7]. This demonstrated that the maps in BR211 (as revised 1992) have limitations that could result in radon protection not being installed where required and vice versa. It was concluded that geological radon potential mapping in general provides the best spatial detail and accuracy as this method relates radon risk to geology — identified as the most important overall control on the concentration of radon in dwellings. A geological radon potential mapping exercise for England and Wales was carried out as part of this research programme using the new BGS 1:250 000 scale lithostratigraphic (bed rock) and the 1:625 000 scale drift digital map data which became available in November 1998. Combinations of bed-rock and drift (unconsolidated deposits) with geological radon potentials considered to require protection were mapped and converted into a 5 km grid map for publication in the revised version of BR211. The new radon map (Annex B in BR211 (1999)) is similar in format to the *Radon Atlas of England* (Lomas et al., 1996), except that it shows those grid squares which are underlain, completely or in part, by geological units which require protection.

3.13 More detailed geological radon potential data is available for twenty 1:50 000 scale geological map sheets covering the most radon-prone parts of Derbyshire, Northamptonshire, Nottinghamshire, Leicestershire, Lincolnshire, Oxfordshire,

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6 In the UK, geological radon potential indicates the probability that existing dwellings sited on a geological unit will exceed the radon Action Level (200Bq m^{-3}). The radon potential of any combination of bed-rock and drift (unconsolidated deposit) may be determined by statistical analysis of radon measurements made in existing dwellings.

7 *Evaluation of mapping and site investigation methods for targeting areas where new development requires installation of radon protective measures*. British Geological Survey Research Report (in preparation).

Shropshire, Somerset and Yorkshire[8,9]. The main purpose of the 1:50 000 scale maps is to identify localised areas of England where radon concentrations are most likely to have >5% probability of being above the Action Level and to inform any future radon measurement campaigns. Whereas the maps help to identify those areas where radon protective measures are required in new dwellings, they should not be used as the basis for a Stage 2 Geological Assessment (see BR 211 (BRE, 1999)). This is because the information on the 1:50 000 scale maps shows the average radon potential for each geological unit whereas more detailed information may be used to generate the site specific Radon Protective Measures (RPM) Site Reports[10]. The 5 km grid maps derived from the 1:250 000 scale geological radon potential assessment were upgraded to take into consideration the results of the more detailed 1:50 000 scale maps.

3.14 Research has demonstrated that in the far south-west of England (Ordnance Survey 100-km grid squares SW and SX), uranium mineralization can cut across mapped geological boundaries, and grouping house radon data by geological unit may not be the best approach to mapping radon potential. In this area, the NRPB has produced a 1-km grid square radon potential map for the detailed targeting of the requirement for protective measures in new dwellings (Miles and Appleton, 2000).

3.15 In Option BC-3, which applied to the 1996 interim guidance for new dwellings, the developer had the option of applying for relaxation of the requirement for measures based on the results of a geological site investigation (incorporating desk studies, ground investigations and soil gas radon measurements). The site investigation and report would have needed to be executed by a suitably qualified geologist. The technical protocols for soil gas radon measurements and assessment of results were not clearly defined in the interim guidance. Indeed, the reliability of radon site investigations was uncertain at that time and was investigated further as part of the current research programme. The results of this research programme[11] indicate that in most cases it is impractical to assess the severity of a radon problem on a particular site accurately until the building has been constructed and occupied, therefore precautions should be taken in areas where high radon levels have been predicted by the mapping programme. Radon site investigation techniques are not yet reliable enough to be incorporated into guidance. In the interim guidance, it was also noted that the use of the site investigation option to obtain relaxation of requirement for measures is unlikely to be a cost-effective option unless the development is for more than 10–20 dwellings.

3.16 A requirement for a radon site investigation to be carried out on all new development sites (Option BC-4), as is currently required in Sweden, for example, would lead to unnecessary expenditure for both developers and Building Control authorities. This option was not considered further.

Revised Guidance (BR211, 1999)

3.17 Amendments to the guidance document (BR211) have evolved over two years following a DETR consultation exercise[12]. The principal changes in BR211 reflect greater knowledge of radon-prone areas and the advances made in developing practical cost-effective protective measures. In addition, the development of protective measures and the monitoring of their effectiveness indicated that the general approach to radon protection should be reconsidered and embody the findings of recent research.

3.18 In the revised BR211 (1999) it states that ‘There are two main methods of achieving radon protection in new dwellings: passive and active. The passive system involves providing a barrier to the radon. This can usually be achieved by increasing the general airtightness of the damp-protection provided in floors and walls. The active system consists of providing natural or mechanical underfloor ventilation, or a powered radon-extract system, as an integral part of the services of the dwelling. The last two options will incur running and maintenance costs for the life of the building. Passive systems are to be preferred in new houses, although they may need to be supplemented in some areas with provision for active protection.’ No guidance is currently supplied for suspended timber ground floors in dwellings. The DETR is sponsoring research into the protection of this form of construction and will publish the results in due course.

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8 Prepared by the BGS in collaboration with the NRPB for the Radioactive Substances Division of the DETR (Miles and Appleton, 2000).

9 Mapping radon potential on the basis of house radon and geology requires that digitised geological maps are available. The 300 1:50000 scale map sheets covering England are being digitised under the BGS DIGIMAPprogramme, which is scheduled to be complete in 2001. The 5km grid maps in Annex B (BR211) will be upgraded using the spatially more accurate 1:50000 map data.

10 RPM site reports are available from: National Geological Records Centre, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel: 0115 936 3109; Fax: 0115 936 3276; e-mail: ngrc@bgs.ac.uk). Further information and an order form are available on the BGS web site http://www.bgs.ac.uk/radon and will also be available in the near future on http.//www.british-geological-survey.co.uk/

11 *Evaluation of mapping and site investigstion methods for targeting areas where new development requires installation of radon protective measures.* British Geological Survey Research Report (in preparation).

12 DoE Consultation Paper, March 1997: *Proposed amendments to the Approved Document to Part C of the Building Regulations and to Guidance Document BR211— Radon: guidance on protective measures for new dwellings.*

3.19 In the Approved Document to Part C of the Building Regulations, it indicates that the precise areas where radon protective measures should be taken are reviewed by the DETR in the light of advice from the NRPB[13]. The NRPB *Radon Atlas of England* (Lomas et al., 1996) and the *Radon Atlas of Wales* (Lomas et al., 1998) indicated that radon protection was required in more areas than those listed in BR211 (as revised 1992). The 1999 edition of BR211 was published on 11 November 1999 to reflect this change and also the results of the current research project.

3.20 The DETR Building Regulations Division devised a system for determining the level of protection needed based on two sets of maps that show, as 5km grid squares of the National Grid used by the Ordnance Survey, where protective measures from radon will or may be needed. The areas shown on the maps will need to be revised as more information becomes available and the maps will be amended accordingly. The 5 km grid squares can be easily cross referenced to local area Ordnance Survey maps at scales that are used for building control and for planning purposes (e.g. 1:50 000, 1:25 000 or 1:10 000). The two map sets are quite different due to the way they have been prepared. The NRPB maps (Annex A, BR211 (1999)) are based on a statistical analysis of radon measurements in existing houses and show 5 km grid squares for which the estimated percentages of homes above the radon Action Level (AL; 200 Bq m^{-3}) exceed the threshold percentages designated for either basic (3% >AL) or full (10%>AL) radon protection (Figures 1 and 3). The BGS maps (Annex B, BR211 (1999)) are also based on a statistical analysis of radon measurements in existing houses but indicate those grid squares which are underlain, completely or in part, by geological units for which the estimated percentages of homes above the Action Level exceed the thresholds for either basic or full radon protection. The shading on the BGS maps (Figures 2 and 4) shows the highest geological radon potential found somewhere within the grid square rather than the average for the grid square (shown on the NRPB maps). As a result there are many more grid squares shown on the BGS maps (Annex B, BR211) than on the NRPB maps (Annex A, BR211).

3.21 If a site falls within one of the squares shaded on the Annex B (BGS) maps, it does not necessarily mean that it must have radon protection. This is because some of the grid squares contain bed rocks and unconsolidated (drift) deposits with lower radon potential than the maximum levels shown on the map. In many cases the geological radon potential varies considerably within a grid square. In other cases, only a very small area (sometimes only a few hundred square metres) with a radon potential exceeding the thresholds for basic or full protection occurs within the grid square but, as the squares are coded according to the highest radon potential, the whole square has been shaded. The level of protection that might be required is thus site specific, and can be determined by reference to the relevant radon potential map followed by a geological assessment of the site. In BR211 (1999) the two types of map are complementary, and neither should be used in isolation.

3.22 There is a flow chart in the 1999 Edition of BR 211 that sets out a two-stage procedure to be followed when using the maps in the guidance. It makes it clear when full protection should be installed, and when no protection is necessary at all. It also indicates where, when no protection or the installation of basic protection is indicated by the NRPB maps, the BGS maps should be consulted to establish if underprotection might be possible. In Stage 2 of the procedure it is stipulated that a geological assessment should be carried out if the site is in a shaded square on Map 2 and Plates 12 to 22 in Annex B of BR211 (1999). A geological assessment involves checking whether a site is on or close to a geological unit for which either basic or full radon protection is required. Radon Protective Measures (RPM) site reports are generated by the BGS Radon Protective Measures Geographical Information System (RPM-GIS)[14]. The search area (circle or rectangle) used for a site assessment is increased by a buffer zone of 50 m in areas with 1:50 000 scale data and 500 m in areas with 1:250 000 scale data. This is to allow for potential inaccuracies in the position of the geological radon potential boundaries. The geological assessment advisory report indicates the highest level of protection required within the buffered search area. Consideration must be given to installing basic or full radon protection if the geological assessment shows that this is required.

3.23 The two-stage procedure is illustrated in the flow chart in Figure 5 and Table 1.

3.24 There are sectors within some light and dark brown shaded 5 km grid squares shown on the maps in Annex A that are underlain by geological units with radon potential lower than the 3% or 10% thresholds designated for the installation of basic and full measures. In other cases, the developer may encounter geological evidence that could cast doubt on the result of the RPM geological assessment. This evidence might be either from the BGS 1:10 000 scale geological map[15] or from geological site investigations, which would have to be carried out by a qualified geologist. In such situations, builders or their professional advisers may be able to demonstrate that there is no significant danger to health caused by radon in the ground covered by the buildings.

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[13] and the British Geological Survey. The maps in Annex B of BR211 (1999) were produced for the DETR by the BGS in collaboration with the NRPB.

[14] See footnote 10.

[15] For a detailed follow-up geological radon potential assessment based on BGS 1:10000 scale geologicall data contact: Land Survey South Enquiry Service, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel: 0115 936 3192; Fax: 0115 936 3192; e-mail: geohelp@bgs.ac.uk

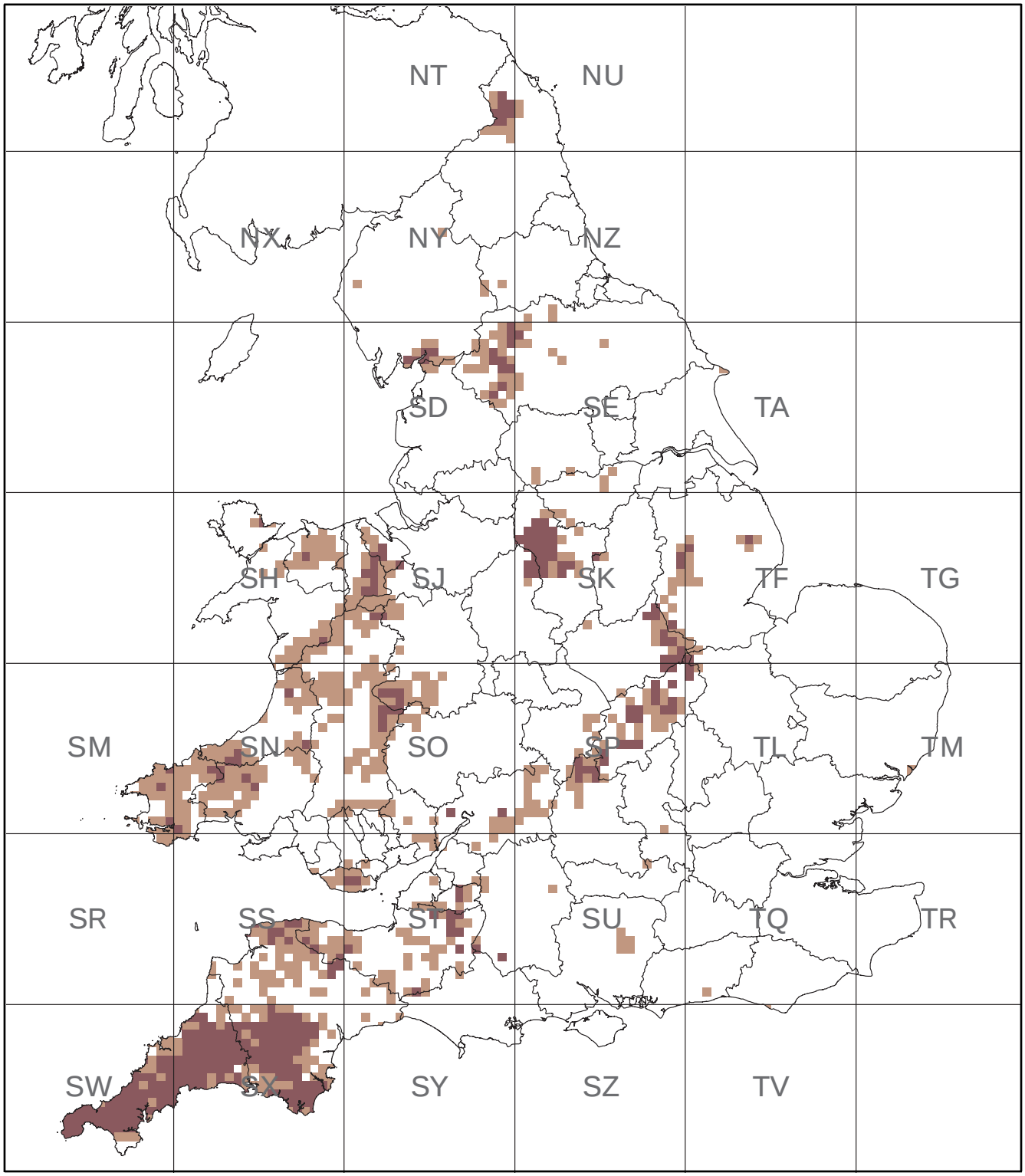

Figure 1 Map 1 (BR211, 1999) showing 5 km grid squares in England and Wales where basic (light brown) and full (dark brown) radon protection should be provided in new dwellings.

The administrative boundaries shown on this map are based upon the OS map by the DETR with the permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence Number: GD272671. (Cartography by BGS on behalf of the DETR; reproduced from BR211 (1999) with permission from the Copyright Unit, HMSO).

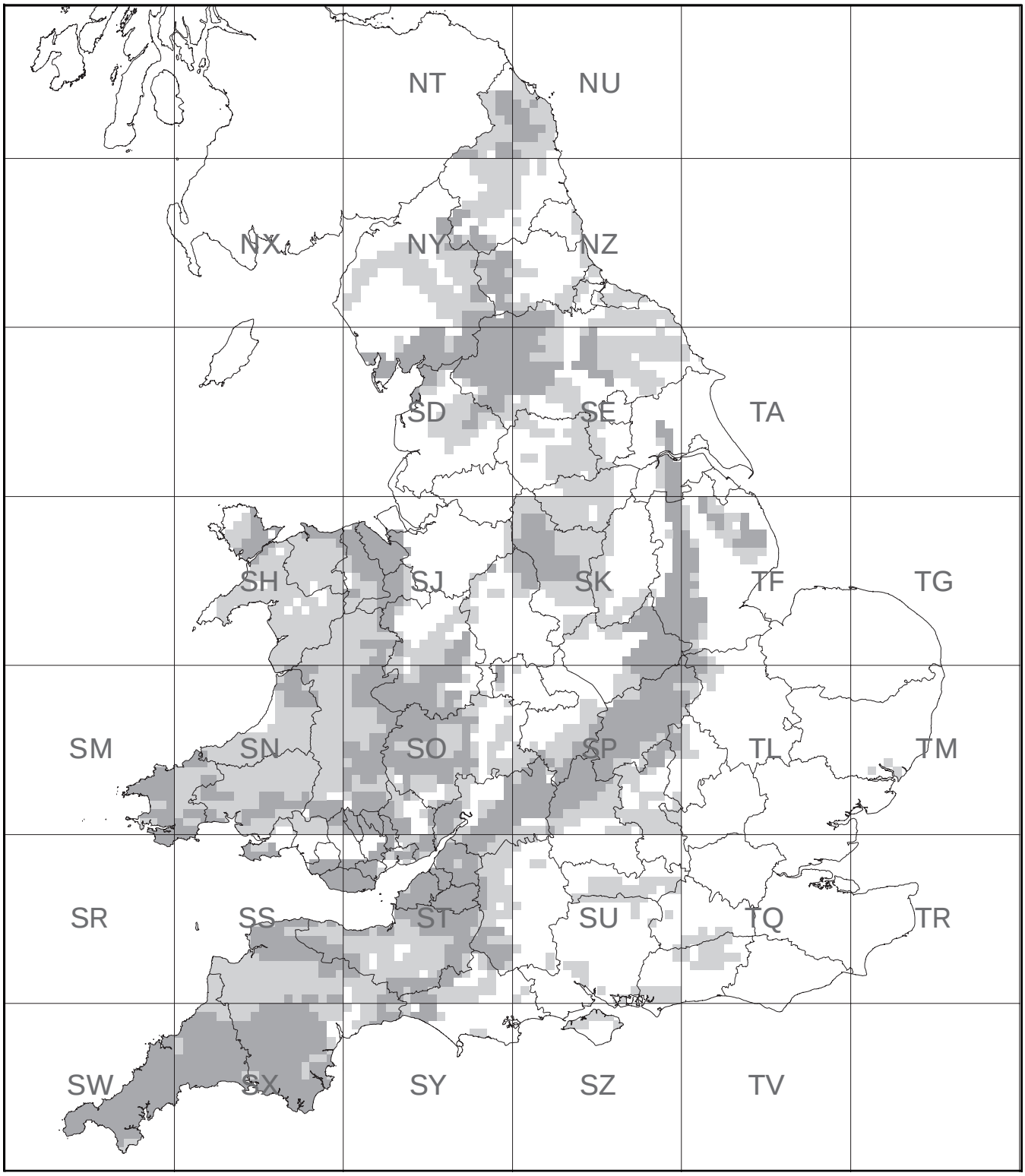

Figure 2 Map 2 (BR211, 1999) showing 5 km grid squares in England and Wales where a geological assessment should be carried out. Shaded squares underlain, completely or in part, by geological units which require basic (light shaded) or full (dark shaded) radon protection to be provided in new dwellings.

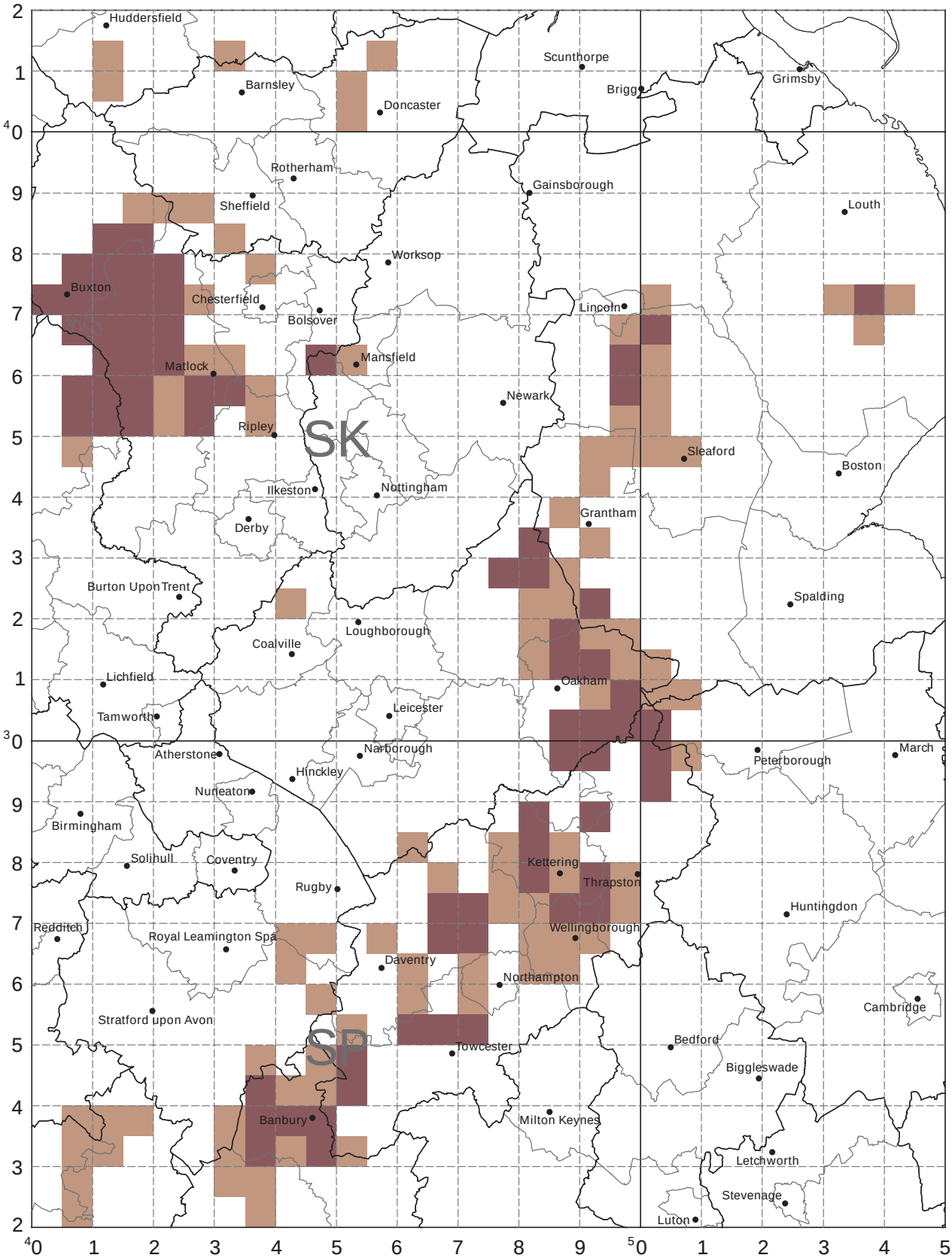

Figure 3 Plate 7 (BR211), 1999) showing 5 km grid squares in the East Midlands where basic (light brown) and full (dark brown) radon protection should be provided in new dwellings.

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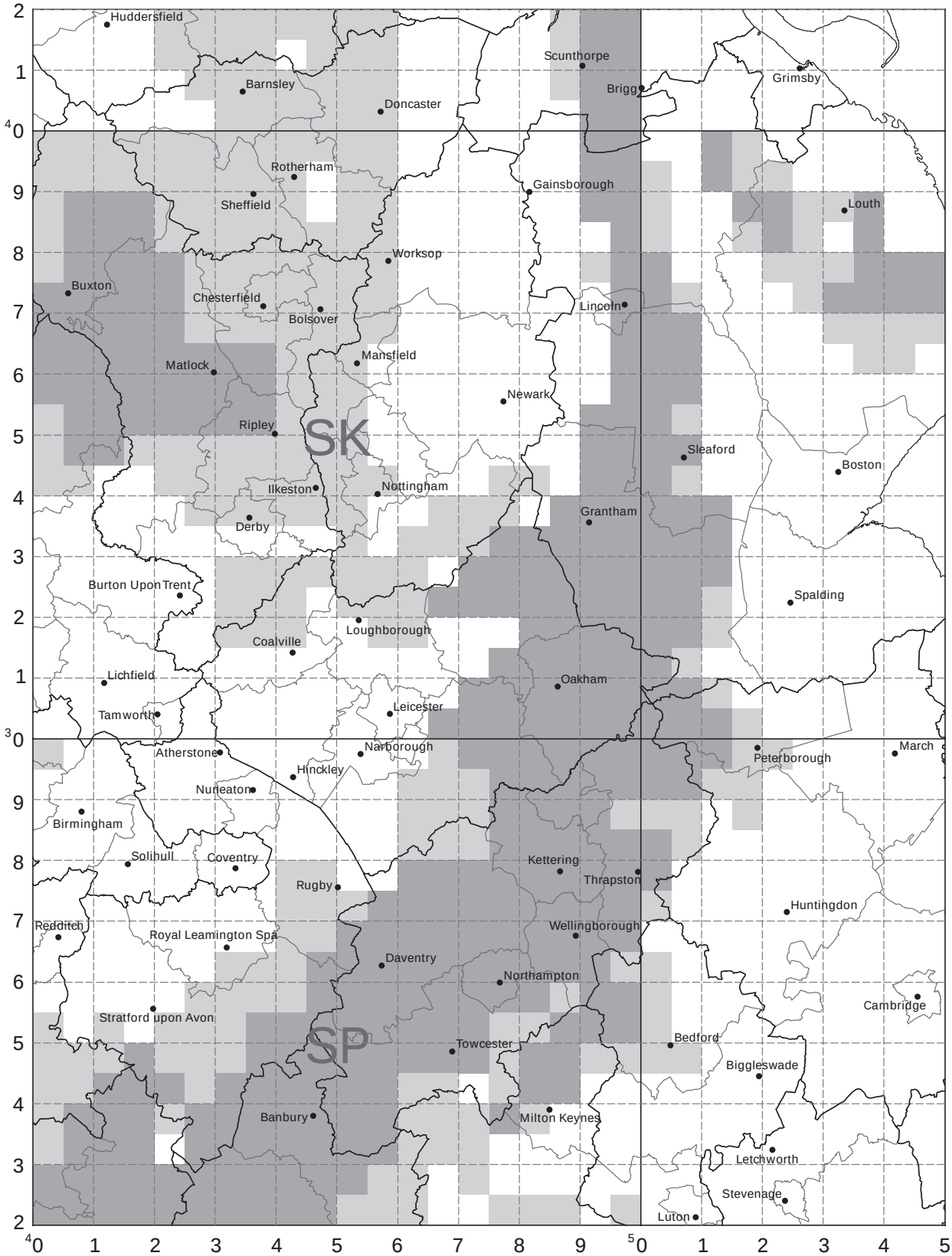

Figure 4 Plate 18 (BR211, 1999) showing 5 km grid squares in the East Midlands where a geological assessment should be carried out. Shaded areas underlain, completely or in part, by geological units which require basic (light shaded) or full (dark shaded) radon protection to be provided in new dwellings.

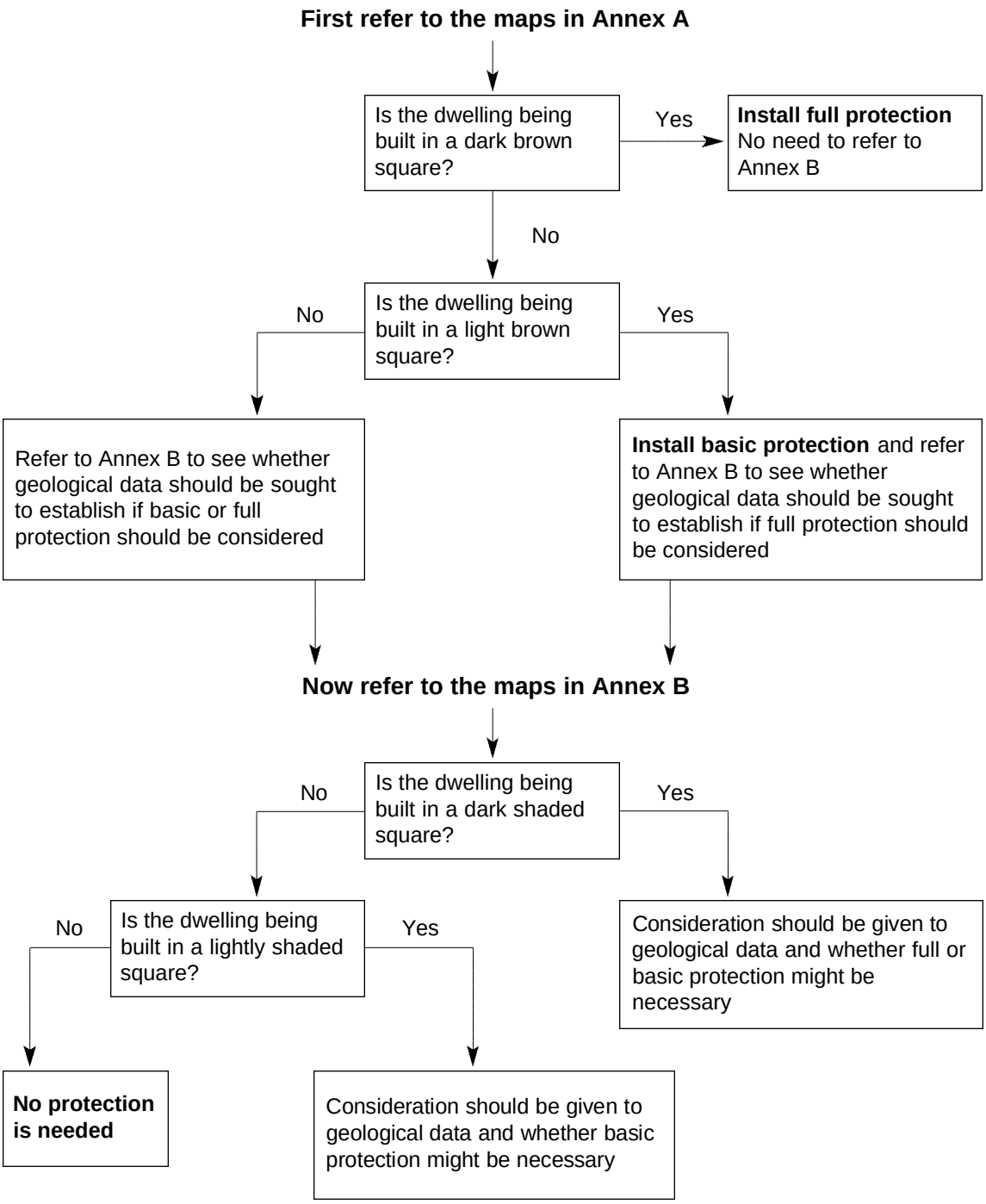

Figure 5 Flow chart indicating how to use the maps in Annexes A and B (BR211) to decide what level of protection is necessary in a new dwelling (reproduced from BR211 (1999) with permission from The Copyright Unit, HMSO).

3.25 In both these situations, the developer would be well advised to consider whether prospective purchasers or occupiers of the dwellings would consider the installation of radon protective measures a positive feature.

3.26 A different approach has been taken in Scotland where NRPB 5 km grid maps are used to identify areas where Stage 1 and Stage 2 protective measures should be incorporated[16]. Stage 1 and Stage 2 protective measures are equivalent, respectively, to *basic* and *full radon protection* in England and Wales. Stage 1 protective measures are required in 5 km grid squares for which the estimated percentages of homes above the radon Action Level (200 Bq m^{-3}) is between 1 and 10%. No account is taken of geological radon potential.

[16] BR376 *Radon: guidance on protective measures for new dwellings in Scotland* (BRE, 1996b)

Table 1 Radon protective measures which should be provided in new dwellings, depending on the shading found in grid squares on maps in Annexes A and B of BR211 (1999 edition)[17].

		Shading of maps in Annex A		
		White	**Light Brown**	**Dark Brown**
Shading of maps in Annex B	**White**	None	Basic	Full
	Light grey	Basic, unless geological report[18] indicates None	Basic	Full
	Dark grey	Full, unless geological report indicates Basic or None	Full, unless geological report indicates Basic	Full

Radon protection in new workplace buildings

Current responses

3.27 Under the *Health and Safety at Work etc. Act 1974* (HSW Act) employers must ensure the health and safety of employees and others who have access to that working environment. Protection from exposure to radon at work is specified in the *Ionising Radiations Regulations 1999* made under the HSWAct. These Regulations apply to workplaces where the level of radon exceeds a defined threshold. For most practical purposes application of IRR99 occurs where the average radon level, measured in the winter months when the levels are usually at their highest, exceeds 400 Bq m^3.

3.28 Regulation 3 of the *Management of Health and Safety at Work Regulations 1999* requires employers to carry out a suitable and sufficient risk assessment to decide what control measures are needed under health and safety regulations. An employer occupying a building as a workplace in a radon-affected area for the first time will need to take into account the radon concentration in that risk assessment. Where the radon in air concentration in the building is above the threshold level in the *Ionising Radiation Regulations 1999* (namely 400 Bq m^{-3}) regulation 7 of those Regulations requires that the assessment is sufficient to identify the measures needed to restrict exposure of persons to ionising radiation. As a consequence it might be considered prudent to include protective measures during construction in radon-prone areas (BR211 (1999), Annexes A and B).

3.29 The technical guidance contained in BR211 (1999) may be of use to designers and builders of new structures whose form of construction and compartmentation is similar to housing and where the heating and ventilation regime is similar to that used in housing. This is likely to include small office buildings and primary schools. Interim guidance on protective measures for new non-domestic buildings is included in BRE Report BR293 *Radon in the Workplace* (BRE, 1995) and on remedial measures relevant to major alterations (such as barn conversions) in BRE Report BR267*: Major alterations and conversions* (BRE, 1994a). These guidance documents offer advice on simple cost-effective measures that can be incorporated during the construction of new buildings or when extending or converting existing buildings. This is seen as interim advice to assist those developers and building owners who want to incorporate measures. The guidance is based on scaled up protective measures of the type recommended for dwellings. The BRE is monitoring sites to assess the effectiveness of the guidance in terms of practical application, minimising radon levels and cost.

3.30 Few local building control authorities actively require protective measures to be installed in new workplaces. Most authorities advise inclusion where appropriate but do not make this a requirement for building regulation approval. Building control conditions would have to be necessary; relevant to the development; enforceable and precise.

Options for dealing with radon in new workplaces

3.31 Although there is clearly a gap within guidance to support the Building Regulations regarding radon protection for workplace buildings, there are a number of reasons that make it difficult to develop similar guidance to that developed for dwellings:

- there is a far wider variation in construction types used, as well as in the size and use of buildings than with dwellings, which make it difficult to offer precise guidance.

[17] Adapted from Environmental Radon Newsletter, Issue 23, p.1.

[18] Geological radon protective measures (RPM) site reports are available from: National Geological Records Centre, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel: 0115 936 3109; Fax: 0115 936 3276; e-mail: ngrc@bgs.ac.uk). Further information and an order form are available on the BGS web site http://www.bgs.ac.uk/radon and will also be available in the near future on http://www.british-geological-survey.co.uk/

- identification of those areas where protective measures in new workplaces should be installed would be difficult using grid square or geological radon potential mapping. This is because the number of radon measurements made in workplaces is very small and the range of workplace types very wide. In addition, monitoring results, unlike those for dwellings where most results are held by the NRPB, are scattered between suppliers of detectors so mapping in the same way as dwellings would be impractical.

3.32 It has been estimated that for a typical open plan factory or warehouse unit with a total floor area of approximately 4000 m^2, the additional cost of installing radon protective measures would be in the region of £1500. This would include the cost of improved sealing of existing damp-proof membranes and provision of eight sumps and manifolded pipework for subsequent connection to extractor fans. This solution in itself will considerably reduce the likelihood of elevated indoor radon levels. However should this prove inadequate and remediation is required, the cost of later installation of two fans is estimated to be approximately £500, giving an overall installation cost of £2000. These costings should be considered as being illustrative.

3.33 The alternative solution would be to install remedial measures as necessary later. It is difficult to put a cost to this, as with a building of this size, remediation would almost certainly be carried out in several stages targeted at the worst affected part of the building first. However, if it is assumed that a similar coverage in terms of subfloor depressurisation is required as the previous example (i.e. eight sumps) and that minimal internal disruption is required, then there would be a need for at least eight separate mini sump systems each fitted with a fan costing approximately £750 per system to install - giving an overall installation cost of £6000.

3.34 A prudent developer, especially in an area where emissions are high, should consider the possibility that radon levels inside the building may be high enough to require protective measures and to provide them at initial construction. This is particularly important for new multi-purpose work place developments. See also para. 4.39 below.

Other types of new development, material alteration and material change of use

3.35 Procedures for dealing with radon protection where there is material alteration or material change of use through the use of planning informatives are outlined in para. 4.14 and Figure 6 of this document. Building Control authorities could adopt a similar system. However, this would have the disadvantage that developers would not become aware of potential radon problems at the pre-planning and planning stage. Because of this, they may incur financial penalties, if for example, buildings had to be re-designed to incorporate protective or remedial measures. Alternatively, Regulation 6 (Material Change of Use) of the Building Regulations could be changed to address these deficiencies.

3.36 For these reasons, a system based on planning informatives may be the most practical option for ensuring that radon protection is adequately dealt with in cases of material change of use (such as barn conversions) or non-domestic development, including workplaces and certain residential institutions. Other types of building are subject to Requirement C2 of the Building Regulations but this could be made clearer if a paragraph on non-domestic building was added to the Approved Document to Part C.

4 Radon and the planning system

Radon as a material planning consideration

4.1 The purpose of the planning system is to regulate the use and development of land in the public interest. The system is also intended to provide guidance — to help people plan the use of their land confidently and sensibly.

4.2 Development control involves the determination of applications for planning permission. Planning permission is required for any development of land. Planning decisions on proposals to build on land or to change its use are usually made by local planning authorities. The system operates on the basis that applications for development should be determined in accordance with the development plan, unless material considerations dictate otherwise.

4.3 Planning Policy Guidance Note 1 (PPG1)[19], which sets out the general policy and principles of the planning system, states that: *'In principle, any consideration which relates to the use and development of land is capable of being a material planning consideration'* (para.50).

4.4 Since radon emissions in new development can pose a risk to people's health, they may be a material planning consideration. It follows, therefore, that local planning authorities should have regard where necessary to the issue of radon emissions in preparing development plans and deciding on planning applications, the aim being to ensure that radon protective or remedial measures are incorporated, where appropriate.

4.5 When considering a potential planning response to the radon issue, analogies can usefully be drawn with land instability and methane emissions, both of which are naturally occurring phenomena. The former is currently addressed in PPG 14 (Development on Unstable Land), which advises local authorities to take account of land stability in preparing development plans and in deciding on planning applications. Recent research into methane emissions and other naturally occurring gases concluded that the issue should be addressed by planning because not all development is subject to control under the Building Regulations (Appleton, Hooker and Smith, 1995; Wardell Armstrong, 1996).

Potential Planning Response

4.6 There are no circumstances where the problem of radon emissions in new development cannot be overcome through appropriate protective or remedial measures. It would therefore be inappropriate for planning permission to be refused solely because of the presence of potentially harmful radon concentrations.

4.7 However, it is considered that the planning process could be used to inform potential developers and the general public of the radon issue and of the requirement or possible need for protective or remedial measures for certain types of development or change of use in radon-prone areas. This information could be provided in development plans and in pre-application discussions. Planning informatives, forming part of a decision notice, would ensure that developers are made aware of the possible requirement for protective or remedial measures under either Requirement C2 of Schedule 1 of the Building Regulations 1991 or the Ionising Radiations Regulations 1999.

4.8 This approach would complement the functions of building control, the HSE and local authority Environmental Health Officers.

The Role of Planning Policy Guidance

4.9 Planning policy guidance would draw attention to these roles of the planning system with respect to radon emissions in new development. Rather than a separate PPG on the subject, it may be more appropriate to combine this guidance with that relating to other physical constraints, such as contaminated land and emissions of methane and other harmful gases.

4.10 Planning policy guidance would seek to advise local planning authorities how radon could be dealt with using the following procedures.

[19] In Wales, refer to *Planning Guidance (Wales): Planning Policy, 1999*

The Role of Development Plans

4.11 Structure Plans and Part 1 of Unitary Development Plans[20] might include a general statement indicating that radon emissions are an issue which local authorities may need to take into account when preparing development plans and determining applications for planning permission. The statement would provide information about the radon issue, its geographical extent, and explain that the problem can be overcome through appropriate protective or remedial measures. Reference would need to be made to the maps in BR211, which would, in effect, be considered as a radon 'constraints map'showing those areas affected or potentially affected by radon emissions. There are probably very few situations where additional detail would be required for planning.

4.12 Local Plans and UDPs Part II would give detailed expression to the general statements in Structure Plans and Part 1 of Unitary Development Plans. They would indicate that, for certain types of development or material change of use in radon-prone areas, protective or remedial measures might be required by Building Control.

The Role of Development Control

4.13 The function of development control, at the pre-application stage, would be to remind applicants that, for development or changes of use in radon-prone areas, protective or remedial measures are likely to be required by Building Control.

4.14 At the planning application stage, subject to other material considerations, planning permission could be granted with an informative that:

- in the case of **new dwellings, extensions to dwellings and material alteration and material change of use** (e.g. major structural alterations and conversions to domestic use, such as barn conversions), radon protective measures may be required by Building Control, in accordance with Requirement C2 of the Building Regulations[21]. The developer would be referred to BR211 (*New dwellings*) or BR267 (*Major Alterations and Conversions*).
- in the case of **new workplaces or new residential institutions**[22], radon protective measures may be required. The developer would be referred to BR293 (*Radon in workplaces*) or alternative detailed guidance, should this be considered necessary[23].
- in the case of a **change from workplace to domestic use which does not involve major structural alterations to floor and foundations (material alterations),** radon monitoring and subsequent remediation may be required. The developer would be referred to BR250 (*Radon remedial measures in existing dwellings*).
- in the case of **change from domestic to workplace or non-domestic residential use**, radon protection, radon monitoring and subsequent remediation may be required. The developer would be referred to BR293 (*Radon in workplaces*)[24].

4.15 Since planning informatives would be a matter of public record, any future purchaser not discovering the risk of radon would be negligent in not doing so. Such information should be included in the *Home Seller's Information Pack,* should this aspect of the DETR's recent initiative[25] to improve co-ordination of the home buying and selling process be adopted. An optional enquiry (No. 36) about radon gas precautions already appears on the local authority searches form (CON. 29 (1994): *Enquiries of Local Authority*).

4.16 A flow diagram illustrating the potential planning response is in Figure 6.

Alternative Approach Using Planning Conditions

4.17 An alternative approach would be to ensure that applications for development or material changes in use which might expose people to significant levels of radon, but are not subject to the Building Regulations, are granted subject to a

[20] In Wales, refer to *Planning Guidance (Wales): Unitary Development Plans, 1996*

[21] A change from agricultural or workplace to domestic use which involves major construction work to floor and foundations, such as a barn conversion, is not subject to Requirement C2 of the Building Regulations. Amendment of Regulation 6 (Material Change of Use) of the Building Regulations (England and Wales) 1991 would help to address this point.

[22] Certain residential institutions are not referred to in Approved Document C to the Building Regulations. These include children's homes and homes for the elderly.

[23] An employer using a workplace would be responsible, under the *Health and Safety at Work etc. Act 1974* and the *Ionising Radiations Regulations 1999*, for ensuring that employees and others who have access to that working environment were protected from exposure to radon.

[24] In Wales, refer to *Planning Guidance (Wales): Unitary Development Plans, 1996*

[25] DETR Consultation Paper The Key to Easier Home Buying and Selling (ISBN 1 85112 134 X)

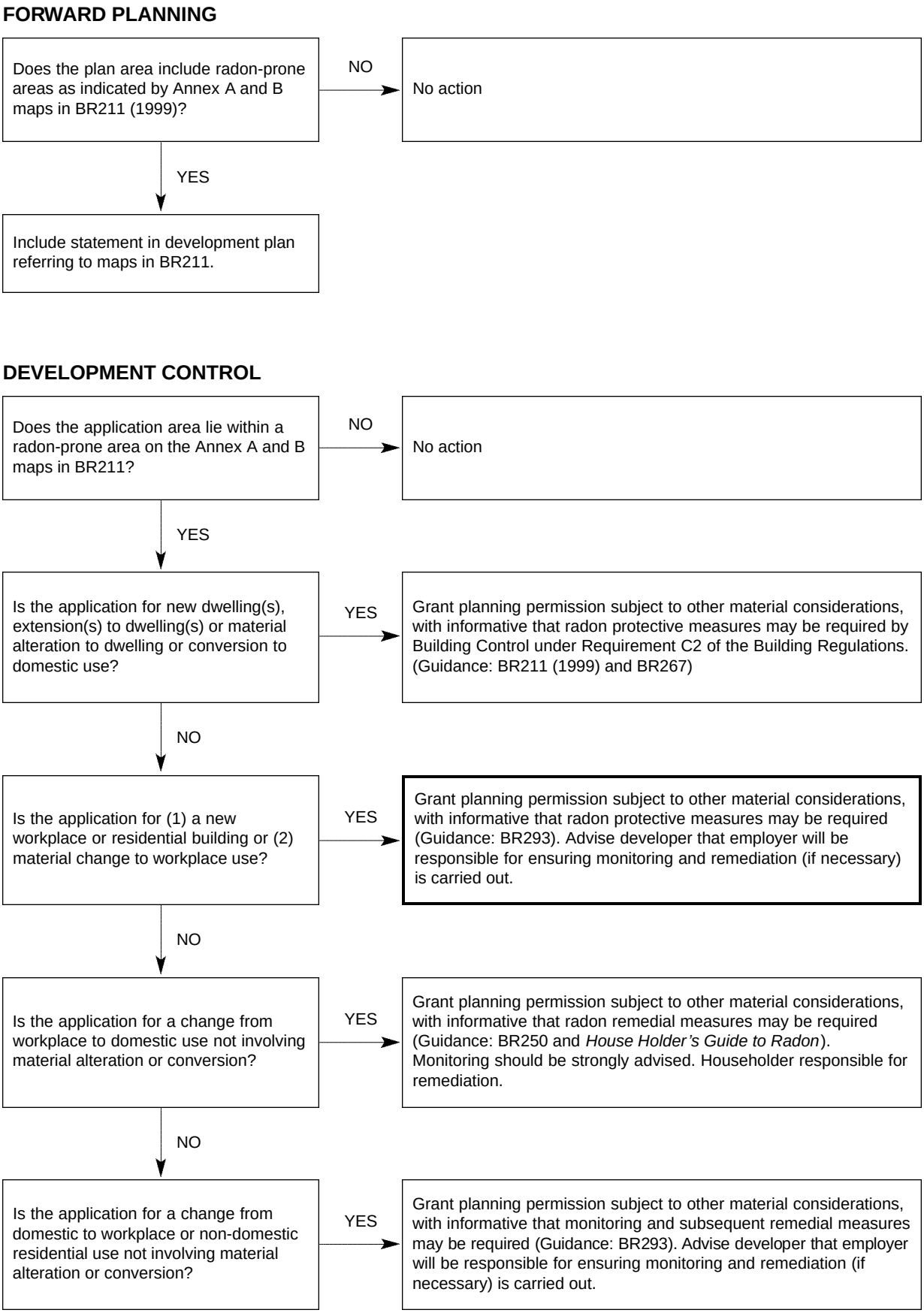

Figure 6 Planning procedures for dealing with radon emissions in new development.

planning condition. The condition would state that the development should not commence until radon protective measures (or the results of investigations which disprove the need for such measures) are submitted to and approved by the local planning authority, in consultation with Building Control.

4.18 With respect to changes of use that do not involve major structural alterations to floor and foundations (material alterations), however, the imposition of conditions would not be practical. This is because radon monitoring has to be carried out over a three month period **after** occupation of the buildings in order to assess whether remedial measures are required. Thus conditions could only be attached to planning approvals for new workplaces, and certain new residential institutions, together with conversions to workplace use which involve major structural alterations to floor and foundations.

4.19 The procedures to be followed if this alternative approach was adopted are identical to those illustrated in Figure 6 with the exception that the fourth box down in the right hand column (outlined in bold) would contain the following text:

Grant planning permission subject to other material considerations, with a condition that radon protective measures (or the results of investigations which disprove the need for such measures) are approved by the local planning authority, in consultation with Building Control (Guidance: BR293).

Response to consultation with the planning professionals

4.20 In November 1997, representatives of the planning profession were consulted regarding the potential role of the planning system in dealing with radon in new development. Consultees are listed in Appendix II. Responses were received from 34 local authorities (44% of those consulted), the Planning Officers' Society, and the Royal Town Planning Institute. The following paragraphs summarise the response to the main issues.

Radon as a material planning consideration

4.21 Virtually all consultees agreed that radon emissions are a material planning consideration and, as such, there should be a planning response of some kind. A few consultees noted that, in radon-prone areas, it is considered that local authorities had a duty at least to notify developers of the issue.

Role of Planning Policy Guidance

4.22 To this end it was generally agreed that planning policy guidance should draw attention to the issue of naturally occurring radiation and advise local planning authorities on the appropriate response at the development plan stage and at the development control stage. It was felt that this 'endorsement' of the issue at the national level is necessary to ensure a consistency of approach in the regions - particularly as far as the responses of the Government Offices and the National Assembly of Wales to draft development plans are concerned.

4.23 The general consensus was that the radon issue should be addressed as part of the current revision of PPG 23 on Planning and Pollution Control (Contaminated Land).

Role of development plans

4.24 Most consultees considered that the role of development plans should be to inform developers and the general public of radon-prone areas, and that for certain types of development or land use change in such areas, building control may require radon protective measures. Given that the purpose would be to provide information, rather than a basis for development control, it was considered the radon issue should be addressed as part of the text of a plan — as opposed to a policy statement.

4.25 South Gloucestershire Council included with its response a relevant extract from the South Gloucestershire Draft Local Plan:

> *Some contaminants occur naturally. In some areas within South Gloucestershire radon emissions are such that protective measures may be required under the Building Regulations. The National Radiological Protection Board will carry out radon tests.* (para. 3.247)

4.26 The Planning Officers Society highlighted the need for guidance from the DETR on how the spatial extent and seriousness of the radon risk can be mapped as accurately as possible.

Role of development control

4.27 It was generally considered that the role of the development control process should also be informative. At the pre-application stage the function of development control would be to remind applicants that for certain types of development or land use change in radon-prone areas, protective measures may be required by building control.

4.28 At the planning application stage, planning permission for development in radon-prone areas should be granted (subject to other material considerations) with relevant informatives (or advisory notes) about the Regulations and legislation applying to the development concerned. Some concern was expressed about the legal or other means by which developers and subsequent owners are required to pass on the information to new owners. Disclosure to new owners is dealt with to some extent by Optional Enquiry 36 on the Law Society search form[26], which asks if the house is in an area where radon precautions are needed.

4.29 It was widely recognised that the informative approach has limitations - not least that informatives are not enforceable. However, the use of planning conditions to overcome this problem was considered generally to be inappropriate. Two main reasons were given.

4.30 First, it is debatable whether such a condition would be consistent with DOE Circular 11/95 (The Use of Conditions in Planning Permissions), which explains that, in considering whether a particular condition is necessary, authorities should ask themselves whether planning permission would have to be refused if that condition was not to be imposed.

4.31 Second, the condition could only be attached to planning approvals for new workplaces and certain new residential institutions, together with conversions to workplace use which involve major structural alterations to floor and foundations. With respect to changes of use which do not involve major structural alterations to floor and foundations, the imposition of conditions would not be practical because radon monitoring has to be carried out over a three month period *after* occupation of the buildings in order to assess whether remedial measures are required.

4.32 This prompted a number of consultees to say that a better solution would be to extend the scope of control under the Building Regulations to cover, in addition to new dwellings:

(i) new workplaces and new residential institutions (e.g. homes for children and the elderly) or major conversions to workplace use;

(ii) change from workplace to domestic use which does not involve major structural alterations to floor and foundations; and

(iii) change from domestic to workplace or non-domestic residential use not involving major alteration or conversion.

4.33 It was felt that such an approach is more appropriate than using the planning process as an 'intermediary' between developers and building control. It is also more logical because the solutions lie in the details of construction, which in themselves are not planning considerations.

4.34 In the absence of such an extension to the Building Regulations, however, some consultees argued that the planning condition approach (where practical) does offer a means of achieving the desired goal - that radon protective and remedial measures are incorporated as far as possible in radon-prone areas.

Conclusions and recommendations

4.35 Most planners consulted agree that the planning system should address the problem of radon emissions in new development. The role of the planning system, however, should be confined to the provision of information about the problem and how it can be overcome (i.e. the relevant Building Regulations and Health and Safety Legislation). The information should be contained in development plans and in decision letters about individual planning applications.

4.36 Maps 1 and 2 of BR211 (1999) (reproduced in Figures 1 and 2) could be combined to produce planning 'constraints maps'. These would indicate those areas where informatives need to be attached to planning decision notices for new development and changes of use.

4.37 An informative might be worded: *It is possible that land covered by the development application lies within a radon-prone area and that radon protective measures may be required by Building Control under Requirement C2 of the*

[26] CON.29 (1994) Enquiries of Local Authority (1994 Edn.)

Building Regulations (Guidance BR211 and BR267). You are advised to follow the appropriate guidance to verify whether protective measures <u>are</u> required. The wording of the informative could be modified to cover the other three cases given in the right-hand boxes of Figure 6. There might be some merit in printing all four informatives as standard on Planning Permission forms in order to avoid errors of omission. Inappropriate informatives could be deleted.

4.38 The planning system should not, in the opinion of most planners consulted, be used as a means of ensuring that the appropriate Building Regulations and Health and Safety Legislation are effectively enforced. This should be done by the relevant administrative structures themselves. For this reason, amongst others, planning conditions should not be used with respect to radon emissions in new development.

4.39 There is a perception that the Building Regulations and Health and Safety legislation do not cover all forms of development or land use change potentially affected by radon emissions which are potentially prejudicial to health (or are above the 'Action Level'). This may be because the information in the Approved Document to Part C and supplementary guidance is limited to new dwellings. In fact Requirement C2 of the Building Regulations applies to all new buildings. Its application to material changes of use is limited because the scope of Regulation 6 is restricted to selected requirements of Schedule 1, which does not currently include Requirement C2. It would be better if these limitations did not have to be addressed through the planning system (apart from through the provision of information). These limitations could be dealt with by appropriate amendments to the Building Regulations.

4.40 Whereas radon may be material to a new development, it is effectively covered in most situations by other legislation. A simple informative attached to planning permissions would meet any perceived duty of local authorities to inform of potential hazards in those cases where it isn't covered by current legislation and would do no harm in cases which are covered.

4.41 The potential planning response outlined above appears to deal effectively with the last three of the limitations of current responses identified in paragraph 1.5 above.

5 Recommended framework for guidance

Introduction

5.1 There are four main categories of new development or changes to use of land in radon-prone areas which may result in people being exposed to radon emissions. These are:

Category 1 — new dwelling(s) or extension(s) to dwellings; material alteration to dwellings or conversion to domestic use;

Category 2 — new workplaces or residential institutions or material changes to workplace use;

Category 3 — change from workplace to domestic use not involving material alteration/conversion;

Category 4 — change from domestic to workplace or non-domestic residential use not involving material alteration or conversion.

5.2 The following sections provide recommendations on how radon in new development should be dealt with through Planning, Building Control, Health & Safety and Environmental Health systems.

Planning

5.3 The role of the planning system should be confined to the provision of information about the problem of radon emissions in new development and how it can be overcome (i.e. through the application of relevant Building Regulations and Health and Safety Legislation and the provision of information about relevant guidance). The information should be contained in development plans and in decision letters about individual planning applications.

5.4 A flow diagram (Figure 6) and paras. 4.6–4.16 provide more detail on how this could be achieved.

5.5 It is recommended that the radon issue should be addressed as part of the current revision of PPG 23 on *Planning and Pollution Control (Contaminated Land)* and the Technical Advice Note (TAN) on *Planning, Pollution Control and Waste Management* in Wales.

Building Control

5.6 It is the purpose of Building Control to ensure that, for certain types of development where the Building Regulations apply, the detailed design of buildings will ensure that the completed building provides a healthy and safe environment for people in and around it.

5.7 Statutory requirements relating to radon are contained in Requirement C2 of Schedule 1 of the Building Regulations 1991 for England and Wales which states: ‘Precautions shall be taken to avoid danger to health and safety caused by substances found on or in the ground to be covered by the building’.

5.8 The Approved Document[27] refers to BRE Report, BR211, *Radon: Guidance on protective measures for new dwellings*, for detailed guidance on where such protection is necessary and practical construction details. The guidance in the Approved Document is limited to new dwellings and extensions but the requirement applies to all buildings. Additional guidance is available for workplaces (BR 293) and for remedial measures in existing dwellings (BR 227 and BR 250).

5.9 Whereas buildings other than dwellings are subject to Requirement C2 of the Building Regulations, this could be made clearer if a paragraph on non-domestic building was added to the Approved Document to Part C.

5.10 The maps and plates in BR211 (1999) and the BGS Radon Potential Measures GIS provide information on the location of those areas where radon protective measures are required in new dwellings and extensions to dwellings (Category 1 in 5.1 above). These maps could also be used to indicate where it may be advisable to install protective measures in

[27] Building Regulations (England and Wales) 1991, Approved Document C, site preparation and resistance to moisture, London, HMSO, 1991.

Category 2 developments and where it may be advisable to monitor for radon in Category 3 and 4 developments, in order to verify whether remedial measures are required.

Health & Safety and Environmental Health

5.11 Regulations and guidance designed to protect the health and safety of employees and others who have access to work-places are enforced by the HSE and Local Authority Environmental Health Departments (LAEHD).

5.12 Employers occupying Category 2 and 4 developments in radon-prone areas for the first time would be responsible for carrying out a suitable and sufficient radon risk assessment. Such employers might be reached, where appropriate, through HSE's workplace contact officers.

Scotland and Northern Ireland

5.13 Whereas this report is directed towards dealing with radon emissions in new development in England and Wales, many aspects of the framework for guidance would also be applicable, in principle, to new development in Scotland and Northern Ireland. Guidance on radon protective measures for new dwellings has been issued in Scotland (BR376, BRE, 1999b).

Appendix I

Background information on radon

Useful information on radon in existing dwellings is given in the following free publications which can be obtained by writing to: DETR Free Literature, PO Box 236, Wetherby, West Yorkshire, LS23 7NB.

Radon — A Householder's Guide

Radon — You Can Test for it

Radon — A Guide for Homebuyers and Sellers

Radon — A Guide to Reducing Levels in Your Home

Information in the booklets is also available on the DETR website at: *http://www.environment.detr.gov.uk/radioactivity/index.htm*

You can get advice about radon, its health risks and details of how to order the radon test from the NRPB Radon Freephone on 0800 614529 or by post from NRPB, Chilton, Didcot, Oxfordshire OX11 0RQ.

Accumulations of radon in dwellings can be fairly easily and inexpensively dealt with. You can get practical advice about construction work to reduce radon levels from the Building Research Establishment (BRE) Radon hotline on 01923 664707.

The Ionising Radiation Regulations, 1999, require employers to take action when radon is present above a defined level in the workplace. Advice may be obtained from your local Health and Safety Executive Area Office or the Environmental Health Department of your local authority. The BRE publishes a guide: *Radon in the workplace* (BR293).

BRE publications may be obtained from Construction Research Communications Ltd, 151 Roseberry Avenue, London EC1R 4QX (Tel: 020 7505 6622; Fax: 020 7505 6606).

Geological radon potential assessment methods are described in the British Geological Survey Technical Report WP/95/2 Radon *and back - ground radioactivity from natural sources: characteristics, extent and relevance to planning and development in Great Britain* which may be obtained from the Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG (Tel: 0115 936 3241; Fax: 0115 936 3488).

A comprehensive list of publications about radon with details of prices and how to obtain them is published in the *Environmental Radon Newsletter*, Issue 16 (Autumn 1998) available from the NRPB.

Appendix II

Planning consultees

1 The chief planning officers of all local authorities (counties and districts/boroughs) in the radon Affected Areas listed in BR211(as revised 1992) (5 counties and 49 districts in total);

2 The chief planning officers of all local authorities (counties and districts/boroughs) in additional radon-prone areas (selected on the basis of the geological radon potential map published by BGS in 1995[28]) (11 counties and 12 districts in total);

3 The Planning Officers' Society;

4 The Royal Town Planning Institute.

[28] 1:625000 scale Radon Potential Based on Solid Geology maps of Great Britian (North and South sheets) in Appleton and Ball (1995).

Appendix III

References

ÅKERBLOM, G. 1999. *Radon Legislation and National Guidelines.* Statens strålskyddinstitut Report No. 99:18 (Stockholm: Swedish Radiation Protection Institute (SSI)). (Also available at http://arcas.nuclear.mech.ntua.gr/~erricca/erriaker.pdf)

APPLETON, J D, and BALL, T K. 1995. Radon and background radioactivity from natural sources: characteristics, extent and relevance to planning and development in Great Britain. *British Geological Survey Technical Report* WP/95/2.

APPLETON, J.D, HOOKER, P J, and SMITH, N J P. 1995. Methane, carbon dioxide and oil seeps from natural sources and mining areas: characteristics, extent, and relevance to planning and development in Great Britain. *British Geological Survey Technical Report*, WP/95/1

APPLETON, J.D, and BALL, T K. In press. Geological radon potential mapping. In *Geoenvironment mapping: methods, theory and practice*. BOBROWSKY, P (editor). (Rotterdam: Balkema.)

BARNET, I. 1994. Radon risk classification for building purposes. In *Radon Investigations in the Czech Republic.* BARNET, I, and NEZNAL, M (editors). *V*: 18–25. (Prague: Czech Geological Survey.)

BARNET, I, and MIKŠOVÁ, J. 1999. The GIS approach to radon risk mapping in the Czech Republic. *5th International Conference on Rare Gas Geochemistry, Debrecen, Hungary*.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1991a. Radon: guidance on protective measures for new dwellings. *Building Research Establishment Report* BR 211.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1991b. Construction of new buildings on gas-contaminated land. *Building Research Establishment Report* BR 212.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1993. Surveying dwellings with high radon indoor levels: BRE guide to radon remedial measures in existing dwellings. *Building Research Establishment Report* BR 250.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1994a. Major alterations and conversions. *Building Research Establishment Report* BR 267.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1994b. Radon and buildings: 3. Protecting new extensions and conservatories. *Building Research Establishment Report* XL 10.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1995. Radon in the workplace. *Building Research Establishment Report*, BR 293.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1998. Radon sumps: BRE guide to radon remedial measures in existing dwellings. *Building Research Establishment Report*, BR 227 (Second edition).

BUILDING RESEARCH ESTABLISHMENT (BRE). 1999a. Radon: guidance on protective measures for new dwellings. *Building Research Establishment Report*, BR 211.

BUILDING RESEARCH ESTABLISHMENT (BRE). 1999b. Radon: guidance on protective measures for new dwellings in Scotland. *Building Research Establishment Report*, BR 376

BURIAN, I, MERTA, J, ETAL. 1993. Estimation of the category of radon risk emission on individual building area questions and different approaches. 18–21 in *Radon Investigations in the Czech Republic IV*. BARNET, I (editor). Czech Geological Survey, Prague.

DEPARTMENT OF THE ENVIRONMENT. 1992a. PPG1 (General policy and Principles).

DEPARTMENT OF THE ENVIRONMENT. 1992b. PPG12 (Development Plans and Regional Planning Guidance).

DEPARTMENT OF THE ENVIRONMENT. 1996. PPG 14 (Development on Unstable Land).

DEPARTMENT OF THE ENVIRONMENT. 1994. PPG 23 (Planning and Pollution Control).

DEPARTMENT OF THE ENVIRONMENT. 1995. Circular 11/95 (The Use of Conditions in Planning Permissions).

EPA. 1994. *Model Standards and Techniques for Control of Radon in New Buildings*. US Office of Air and Radiation (6604-J), EPA 402-R-94-009, March 1994 (also available at http://www.epa.gov/iaq /radon/pubs/newconst.html).

LOMAS, PR, GREEN, B M R, MILES, J C H, and KENDALL, G M. 1996. Radon Atlas of England. *National Radiation Protection Board*, Chilton. NRPB-R290.

LOMAS, PR, GREEN, B M R, and MILES, J C H. 1998. Radon in Dwellings in Wales: Atlas and 1998 Review. *National Radiation Protection Board*, Chilton. NRPB-R303.

MATOLÍN, M. 1996. Reference sites for measurement of radon volume activity in soil air in the Czech Republic. In 72–77 *Radon Investigations in the Czech Republic VI.* BARNET, I, and NEZNAL, M (editors). (Prague: Czech Geological Survey.)

MILES, J C H. 1998. Mapping radon-prone areas by log-normal modelling of house radon data. *Health Physics*, 74(3): 37–378.

MILES, J C H, and BALL, T K. 1996. Mapping radon-prone areas using house radon data and geological boundaries. *Environment International.* 22 (Suppl. 1): 779–782.

MILES, J C H, GREEN, B M R, LOMAS, P R, and CLIFF, K.D. 1990. Radon affected areas: Cornwall and Devon. *Documents of the NRPB* 1(4): 37–43.

MILES, J C H, GREEN, B M R, and LOMAS, P R. 1992. Radon affected areas: Derbyshire, Northamptonshire and Somerset. *Documents of the NRPB* 3(4): 19–28.

MILES, J C H, and APPLETON, J D. 2000. Identification of localised areas of England where radon concentrations are most likely to have >5% probability of being above the Action Level. DETR Report No: DETR/RAS/00.001.

NEZNAL, M, NEZNAL, M, and Šmarda, J. 1996. Assessment of radon potential of soils — a five-year assessment. *Environment International* 22(Suppl. 1): 81–828.

NORDIC RADIATION PROTECTION INSTITUTES IN DENMARK, FINLAND, ICELAND, NORWAY, SWEDEN. 1986. *Naturally Occurring Radiation in the Nordic Countries: Recommendations*

SNIHS, JO. 1992. Swedish Radon Programme. In *Radon 2000 Conference Proceedings.* O'RIORDAN, M C O, and MILES, J C H (editors). *Radiation Protection Dosimetry*, Vol. 42, No. 3, 1–184.

USGS (UNITED STATES GEOLOGICAL SURVEY). 1992. *Geologic Radon Potential of EPA Regions 1–10.* U.S. Geological Survey Open File Reports.

WARDELL ARMSTRONG. 1996. *Methane and Other Gases from Disused Coal Mines: The Planning Response. (*London: Wardell Armstrong, TSO.)

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