Environmental geology may be defined as the interaction between people and their physical environment. As such, it is of direct relevance to many aspects of land use planning.

The Department of the Environment, Transport and the Regions (**DETR**) plays a major role in promoting awareness of environmental geology issues as part of its Minerals, Land Instability and Waste Planning Research Programme. The main objective of the research programme has been to provide information relating to these issues that is needed for the development of policy with respect to land use planning in Great Britain.

Between 1994 and 1998, the Department commissioned four research projects to demonstrate the importance of environmental geology and the practical use of associated ***'Earth Science Information'*** in a range of different planning situations:

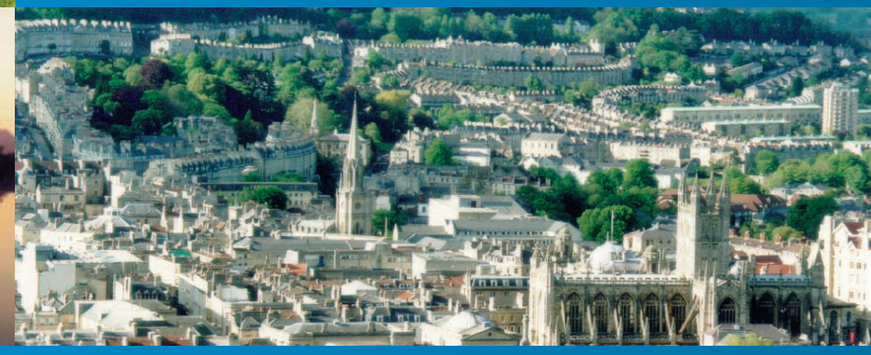
The Use of Earth Science Information in Coastal Planning.
(1994–1996. Consultants: ***Rendel Geotechnics****)*

The Use of Earth Science Information in Support of Major Development Initiatives.
(1995–1997. Consultants: ***British Geological Survey*** *in association with* ***Roger Tym & Partners****)*

The Use of Earth Science Information in Urban Planning.
(1996–1998. Consultants: ***Symonds Group****)*

The Use of Earth Science Information in Rural & Upland Planning.
(1996–1998. Consultants: ***Symonds Group****)*

This guide, prepared by the British Geological Survey, is one of several reports arising from these studies. It is a comprehensive survey of the great variety of available earth science information. An indication is given about which information is most relevant to regional, local and site specific use, and where it can be found.



DETR
ENVIRONMENT
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REGIONS

Environmental Geology in Land Use Planning

A guide to sources of earth science information for planning and development

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British Geological Survey

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R Ellison & A Smith

Price £10

British Geological Survey

Technical Report WA/97/85

A guide to sources of earth science information for planning and development

R A Ellison and A Smith

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BRITISH GEOLOGICAL SURVEY

TECHNICAL REPORT WA/97/85

This study was commissioned by the Department of the Environment, Transport and the Regions (Contract No. MPO 617), but the views expressed in it are not necessarily those of the Department.

Geographical Index

England and Wales

Subject Index

Land-use planning development
earth science information
geological information
soils information

A guide to sources of earth science information for planning and development

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ELLISON, R A, and SMITH, A. 1997. A guide to sources of earth science information for planning and development. *British Geological Survey Technical Report* WA/97/85.

This report can be accessed on the BGS Web pages www.bgs.ac.uk

Keyworth, Nottingham British Geological Survey 1998

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desk at the Survey headquarters, Keyworth, Nottingham. The more popular maps and books may be purchased from BGS-approved stockists and agents and over the counter at the Bookshop, Gallery 37, Natural History Museum, (Earth Galleries), Cromwell Road, London. Sales. Sales Desks are also located at the BGS London Information Office, and at Murchison House, Edinburgh. The London Information Office maintains a reference collection of the BGS publications including maps for consultation. Some BGS books and reports may also be obtained from the Stationery Office Publications Centre or from the Stationery Office bookshops and agents.

The Survey publishes an annual catalogue of maps, which lists published material and contains index maps for several of the BGS series.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

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Murchison House, West Mains Road, Edinburgh, EH9 3LA
✆ 0131–667 1000 Telex 727343 SEISED G
Fax 0131–668 2683

London Information Office at the Natural History Museum, Earth Galleries, Exhibition Road, South Kensington, London, SW7 2DE
✆ 0171–589 4090 Fax 0171–584 8270
✆ 0171–938 9056/57

St Just, 30 Pennsylvania Road, Exeter EX4 6BX
✆ 01392–278312 Fax 01392–437505

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

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB
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Fax 01491-692345

Parent Body

Natural Environment Research Council
Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU
✆ 01793–411500 Telex 444293 ENVRE G
Fax 01793–411501

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1 INTRODUCTION

Earth science information describes the distribution and properties of deposits at the surface and below ground, and the processes that affect the deposits, including the activities of man.

This report provides information in answer to four questions that might be asked in connection with the use of earth science information in support of planning and development.

1 What kind of earth science information is available?

There is a wide range of earth science information which in this report is divided into 13 topics:

- national review projects
- applied mapping projects
- geological maps, reports and databases
- soil maps, reports and databases
- aquifer data, including groundwater vulnerability and flood risk
- engineering geology and site investigation
- mineral resource distribution
- geochemistry of water and soils
- geophysical investigations
- remote sensing (air photographs, satellite imagery)
- historical natural events
- information on sites of geolgical and geomorphological significance
- land-use.

For each topic a brief description of the range of information is given. Most of the information referred to is published, and therefore relatively accessible, and includes databases available for public access.

2 Where can the information be found?

Key addresses, regarded as the primary sources of information, are given under each topic.

3 What are the main uses of the information?

Potential uses of the information are divided into three categories which are related to the scale of involvement, namely stategic, local and site specific. The main uses in each category are as follows:

Strategic level

national, regional and structure planning
minerals and waste management planning
environmental protection
protection of water resources

Local level

local planning
development control in local authorities
protection of water resources
site selection by developers
preparation of development briefs by planning authorities
environmental health

Site specific level

site development
geotechnical and civil engineering
site design
development control in local authorities
building control
environmental statements

An indication of the appropriate use of information in each topic is shown in tables in the following sections.

4 What use is the information for specific planning and development issues?

Planning and development issues include several which need earth science information. The information needed falls into seven “earth science factors”:

- derelict land and contaminated land
- ground stability
- groundwater pollution
- mineral resources
- flooding
- soil resources
- conservation of earth science sites

The importance of specific earth science information for each of these factors is illustrated in Table 1.

Table 1 Earth science factors and key types of information associated with them

● major significance

◯ minor significance

Key Types of Earth Science Information	Key Earth Science Factors						
	derelict and contaminated land	ground stability	water resources and groundwater pollution	mineral resources	flooding	soil resources	conservation of earth science sites
national review projects		●		●	●		
applied mapping projects	●	●	●	●	◯	●	◯
geological maps, reports and databases	●	●	◯	●			◯
soil maps, reports and databases	◯	◯	◯		◯	●	◯
aquifer data; groundwater vulnerability and flood risk			●		●		◯
engineering geology and site investigation	●	●					
mineral resource distribution	◯	◯	◯	●			
geochemistry of water, soils	●		●				
geophysical investigations		◯		◯			◯
remote sensing (air photographs, satellite imagery)	◯	◯			◯		◯
historical natural events		◯			◯		
information on geological sites such as RIGS; SSSIs				◯			●

2 NATIONAL REVIEW PROJECTS

Principal contact for information:

Department of the Environment, Transport and the Regions
Minerals & Waste Planning Division
Zone 4/A2
Eland House
Bressenden Place
London SW1E 5DU

A series of nationwide review projects to establish the nature and extent of ground related problems in Great Britain, and the best approaches for dealing with them, were commissioned by the Department of the Environment between 1986 and 1995 The scope of these projects is summarised in the following table:

PROJECT	SCOPE
Review of Natural Underground Cavities in Great Britain	Extent of cavities; types and extent of surface instability; techniques for investigation and assessment of instability
Review of Mining Instability in Great Britain	Extent; effects on the land surface; methods of investigation; preventative, remedial and monitoring methods
Review of Landsliding in Great Britain	Nature and extent; methods of investigation, monitoring and treatment; techniques for risk assessment; administrative and legislative provisions
Review of Foundation Conditions in Great Britain	Nature and extent of selected conditions; introduction to site investigation and foundations
Review of Natural Contamination in Great Britain	Contaminants are PHEs (potentially harmful elements), natural radioactivity (including radon), methane, carbon dioxide, oil seeps; transference mechanisms; effects on land use, development
Review of Erosion Deposition and Flooding in Great Britain	Types, causes and extent; problems of their interaction; effects on land use; significance for conservation
Preliminary assessment of Seismic Risk	Quantifies hazard and vulnerability for a range of structures
Other DoE funded projects whose findings are applicable nationally are as follows:	
Applied Soil Mapping for Planning Development and Conservation	Interpretation of soil information; computerisation; integration of climate and land use data; presentation of thematic maps on e.g. erosion risk and potential use maps
Mineral Resource Information for Development Plans	Shows distribution of mineral resources of current and potential economic interest on a county basis

Table 2 National review projects concerned with earth science information

The principal reports from the projects, which in most cases are accompanied by small scale maps covering England and Wales illustrating where the ground-related problems occur, are as follows:

Instability due to natural underground cavities:
Applied Geology Limited. 1994. A review of instability due to natural underground cavities in Great Britain, 2 vols. Available from Rust Environmental, Cranford, Kenilworth Road, Blackdown, Royal Leamington Spa, Warwickshire CV32 6RG.

Mining instability:
Arup Geotechnics. 1992. Review of Mining Instability in Great Britain, Summary Report. (London: HMSO).

Landsliding:
Geomorphological Services Ltd and Rendel, Palmer and Tritton. 1990. National landslides database: final report (2 vols). Unpublished. Can be consulted, by prior arrangement, at the Department of the Environment, Transport and the Regions, Eland House, Bressenden Place, London SW1E 5DU.

Foundation conditions:
Wimpey Environmental Limited and National House Building Council. 1995. Foundation conditions in Great Britain: a guide for planners and developers, Summary Report. (Hayes, Middlesex: Wimpey Environmental Ltd). Available from WIMTEC Environmental Ltd, St Peter's House, 6-8 High Street, Iver, Bucks SLO 9NG.

Natural contamination:
Appleton, J D. 1995. Radon, methane, carbon dioxide, oil seeps and potentially harmful elements from natural sources and mining areas: relevance

to planning and development in Great Britain. British Geological Survey Technical Report WP/95/4. (Keyworth: British Geological Survey). Available from BGS (see p.6 for addresses.)

Erosion, deposition and flooding:
Rendel Geotechnics. 1995. The occurrence and significance of erosion, deposition and flooding in Great Britain. (London: HMSO). Available from Rendel Geotechnics, Norfolk House, Smallbrook, Queensway, Birmingham B5 4LJ.

Seismic risk:
Department of the Environment. 1993. Final Summary Report: Earthquake Hazard and Risk in the UK. (London: HMSO.)

Other projects whose results are applicable nationally are:

Mineral resources:
British Geological Survey. 1995. Mineral Resource Information for development plans. Staffordshire: resources and constraints. British Geological Survey Technical Report WF/95/5. (Keyworth: British Geological Survey). Available from BGS.

Although this project is specific to Staffordshire, the report is one of a series in an ongoing study that will ultimately provide information on mineral resources for the whole of England and Wales.

Soil resources:
Hodgson, J M & Whitfield, W A D. 1990. Applied soil mapping for planning, development and conservation. (London: HMSO.)

This project concerned a pilot project in the Southampton area but is included here as it illustrates a methodology, applicable countrywide, for using interpreted soils information.

INFORMATION SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
national review projects	Summary Report	Summary report	Databases and site specific details
natural cavities maps	1:625 000 1:250 000	1:250 000	
mining instability maps	1:625 000 1:250 000	1:250 000	
landsliding maps	1:250 000	1:250 000	
foundation conditions maps	1:625 000 1:250 000	1:250 000	
natural contamination maps	1:625 000	1:625 000	
erosion, deposition & flooding maps	1:250 000	1:250 000	
seismic risk maps	1:625 000		
mineral resource maps	1:100 000	1:100 000	

Table 3 Source data and potential uses of the national review projects

3 APPLIED GEOLOGICAL MAPPING (AGM) STUDIES

Principal contact for information:

Department of the Environment, Transport and the Regions
Minerals & Waste Planning Division
Zone 4/A2
Eland House
Bressenden Place
London SW1E 5DU

Since the early 1980s, the Department of the Environment has commissioned over 50 applied geological mapping studies of selected areas of Great Britain. Many of these were undertaken within coalfields to improve available information on areas which might be liable to mining subsidence. The remainder of the areas, however, were selected to show a broad range of geological characteristics and planning issues. The aim of these was to develop better approaches to collection, collation and presentation of geological information as a basis for planning, development and conservation. The areas covered by AGMs are shown in Figure 1.

The output from many of these projects is in the form of a summary report and summary maps illustrating planning issues in terms of ground constraints and resources. Accompanying technical reports and thematic map sets are designed to illustrate particular aspects of the earth science information such as unstable land, the location of site investigation information and areas vulnerable to aquifer pollution.

Source for AGM reports by BGS

Sales Desk
British Geological Survey
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3241
Fax: 0115 936 3488

Sources for other AGM reports:

Plymouth (for reference only at)
Department of the Environment, Transport and the Regions
Minerals & Waste Planning Division
Zone 4/A2
Eland House
Bressenden Place
London SW1E 5DU

Chacewater
Freeman Fox Consulting Engineers
25 Victoria Street (South Block)
Westminster
London SW1H 0EX

Bristol
Howard Humphries & Partners
Thorncroft Manor
Dorking Road
Leatherhead KT22 8JB

Torbay & **St Helens**
Rendel Geotechnics
Norfolk House
Smallbrook Queensway
Birmingham B5 4LJ

TYPE OF INFORMATION AND MAIN SOURCES	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Maps BGS, Consultants	Small scale summary maps in reports for planners	1:25 000 Summary Maps	1:10 000 Thematic Maps
Reports BGS, Consultants	Executive summary Summary Report	Summary Report	Technical Report

Table 4 Source data and potential uses of applied geological mapping studies

4 GEOLOGICAL MAPS, REPORTS AND DATABASES

Principal contacts for information:

British Geological Survey
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3109
Fax: 0115 936 3276

British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
Tel: 0131 667 1000

British Geological Survey
London Information Office
Natural History Museum Earth Galleries
Exhibition Road
London SW7 2DE
Tel: 0171 589 4090

British Geological Survey Web Site:
http://www.nkw.ac.uk/bgs/home/html

Geological Society Library
Burlington House
Piccadilly
London WV1 0JU
Tel: 0171 434 9944

Geological maps and accompanying memoirs, reports and databases provide the foundation for most earth science information. They contain much of the specialist basic data from which other earth science information is derived. Interpretation of the information shown on geological maps is best undertaken by a qualified specialist who will be able to determine information on the three dimensional relationships of the units shown on the map.

The British Geological Survey is the UK's national geological survey charged with the task of providing up-to-date geological maps for the whole country. They are published at a variety of scales ranging from 1:2 500 000 to 1:10 000, and listed in the Catalogue of Printed Maps (available free) produced annually. They are available for purchase direct from BGS outlets as detailed below (Figs 2, 3, 4 and 5).

BGS publishes regional and local accounts of the geology in the form of regional guides (Fig 6), memoirs and technical reports. Other local information might be provided by library archives and scientific journals.

The BGS library and the Geological Society libraries are the principal sources of earth science literature. Probably the most effective way of identifying key literature and information sources on the geology of an area is to look at the list of references in a recent BGS memoir or technical report or to make a specific enquiry to BGS.

Geological records and databases

The BGS National Geosciences Records Centre (NGRC) holds unpublished paper records relating to the geology of the UK. These collections include the Survey's archives, work donated to the BGS, and that received by statutory rights, such as records of boreholes deeper than 30 m drilled for minerals and boreholes greater than 15 m drilled to investigate water extraction. There are over 800 000 borehole logs, and 19 000 site investigation reports; some are held in confidence and are not available to the public.

A listing of availability of records is provided free of charge, but there is a charge for purchase of information, details of which can be received from the enquiry desks at the BGS offices.

Geoscience Index

BGS operates a Geoscience Index based on an ArcView Geographical Information System (GIS). It currently holds the following national earth science information datasets and a topographical base; new data are constantly being incorporated:

- Geological map availability and dates of publication:
  - County Series 1:10 560
  - 1:10 000 scale
  - 1:50 000 scale
  - 1:250 000 scale
  - One inch to one mile scale
- Borehole sites and index information (date of drilling; depth of borehole; origin)
- Location of borehole core and samples
- Geophysical data such as locations of gravity, magnetic and aeromagnetic measurement locations
- Location of geotechnical data, including all Soil Mechanics Ltd site investigations
- Archive data including theses and the location of waste sites recorded in a 1972 survey carried out for the Department of the Environment.
- The 1:250 000 scale geological map of the UK

The Geoscience Index can be accessed at the BGS offices listed above.

Digital geological data

The value of digital data for planning and development is in Geographical Information Systems which are increasingly being used by local authorities.

Digital geological maps are becoming available from the BGS, based on information at the 1:10 000, 1:50 000 and 1:250 000 scales.

A current BGS development is an Address-Linked Geological Inventory (ALGI) product in collaboration with the HM Land Registry, Valuation Office, Ordnance Survey and Bristol City Council.

The objective of ALGI will be to provide earth science information on a site specific basis, in the form of a brief

report which describes the basic geology in the vicinity of the site, and draws the reader's attention to earth science considerations, such as underground mining, which may affect the property. The information is now available for Bristol and will be available for Greater London at the end of 1997.

Information on the underground geology of London is available in the LOCUS project at BGS Keyworth.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Geological Maps BGS	1:625 000 1:250 000	1:100 000 1:50 000 1:25 000	1:10 000
Geological Reports BGS	Regional Guide	Sheet Memoirs for 1:50 000 sheets	Technical Report
Geological records & databases BGS			Borehole site map Borehole records
Geoscience Index BGS	available for consultation	available for consultation	available for consultation
Digital map-based information BGS	1:625 000 maps	1:10 000 maps ALGI Report	1:10 000 maps ALGI Report

Table 5 Types of geological information and their potential uses

5 SOIL MAPS, REPORTS AND DATABASES

Principal contact for information:

Soil Survey and Land Research Centre
Cranfield University
Silsoe Campus
Silsoe
Bedford MK45 4DT
Tel: 01525 863242
Fax: 01525 863253

For information in Scotland:
Macauley Land Use Research Institute
Craigiebuckler
Aberdeen AB9 2QJ

Soil science is a relatively young institution in England and Wales compared with the geological sciences. Following interruption by the Second World War the Soil Survey was re-established to investigate the soils of England and Wales, their spatial distribution, properties and behaviour and the uses to which they could be put. In 1987 the Survey was transferred from the government domain to Cranfield Institute of Technology (now Cranfield University) and assumed the new name of Soil Survey and Land Research Centre (SSLRC) to reflect its broader interests. It is the principal source of information on the soils of England and Wales.

Soil characteristics are inherited from the soil parent material (the geological substrate) and from alteration of the parent material by soil forming processes. These distinctions produce soil types (known as soil series) that can be mapped. Soil map units can consist of one dominant soil series or a combination of soil types depending on the scale of mapping.

Over the years the information amassed by the Soil Survey has provided an essential basis for discussions and decisions about land-use planning, land management, soil protection and, increasingly, environmental issues. Soil information has been available in published and readily available format since 1954. The paper-based reports usually consist of an Ordnance Survey base map with a printed overlay of soil boundaries delimiting the areas of each soil series (soil map units), either uncoloured (outline), or coloured for ease of interpretation. Each map unit is labelled using a standardised system with the label acting as cross-reference to a brief explanation in a map legend. The soil map accompanies a book, variably described as a Memoir, Bulletin or Record, depending on its format, in which each soil map unit is fully described with analytical data. The book has an introduction which describes the area, its geology and climate, and later sections relate the soils to land evaluation (grading), land use, agriculture and forestry.

A large amount of published soil information is available for the whole country at small scale and for about a quarter of the country at more detailed, large scale. Soil distribution maps are accompanied by reports describing basic soil properties and agricultural interpretations, although some publications gave examples of interpretations more specifically for other users, including engineers and planners. The recent increased interest in and need for soil information across a broad spectrum has encouraged a number of interpretive models to be developed that have been published as paper-based distribution maps or as digital data in GIS applications.

Publication of SSLRC data is derived from the following work programmes:

1:63 360-scale mapping programme (1946-68)

Most of the maps are based on the 3rd Edition 1:63 360 scale (1 inch to 1 mile) Ordnance Survey maps, an identical series to the geological maps of the British Geological Survey. Each map is coloured and covers 561 km^2 (216 square miles) although some are produced as double sheets. There is an explanation of the mapping units on the face of the map and descriptions of profile features, drainage, parent material (geology) and relief. The cover for England and Wales is not complete and the availability of mapped sheets is shown on Figure 10.

1:25 000-scale mapping programme (1968-79)

Maps are either in colour or in outline (monochrome) and are based on the Pathfinder series of Ordnance Survey maps at 1:25 000 (2.5 inches to 1 mile) scale and each sheet covers 100 km^2 (38.6 square miles). The scale allows each individual field or building to be shown on the map, thus giving some precision to locating the changes in soil types across the landscape. Some areas also have published a Land Use Capability map that shows the evaluation for agricultural flexibility and productivity.

The report accompanying each map forms one of a series of records and has introductory sections on the area, its geology and climate, followed by explanations of soil classification and methodology. The important features of each soil type from the area are given with descriptions and analyses of representative soil profiles. Additional chapters relate to land use capability for agriculture and land drainage. Later records in the series have a range of crop suitability interpretations using models incorporating droughtiness and workability limitations of the local soils.

The published maps form a scatter around the country with their distribution shown in Figure 11.

1:250 000-scale National Soil Map programme (1979-82)

The National Soil Map was produced as six regional sheets (Figure 9) at 1:250 000 (quarter inch to 1 mile) scale. The map units are identified by number codes, and are coloured by dominant soil subgroups, of which sixty-seven are recognised. For each unit a map legend shows:

- the geological materials influencing soil characteristics;
- important soil properties and conditions affecting rooting depth cultivations and drainage;
- cropping and other land-use information;
- percentage and area of England and Wales covered by the soil associations.

Urban areas:
An appreciation of the range of soil types in urban areas is given in a project funded by English Nature (Hollis, 1992). Mapping in two pilot areas suggests that the rural soil pattern persists in most suburban areas and it is only in urban centres and extensively disturbed industrial sites that the soil types are severely different and unpredictable.

Key reference:
Hollis, J M. 1992. Proposals for the classification, description and mapping of soils in urban areas. (Peterborough: English Nature.)

1:50 000-scale strategic mapping programme (1982-87)

There are five maps in the series, shown on Figure 10. They incorporate previously surveyed soil information and newly acquired data. Each covers 1600 km^2 of a standard Ordnance Survey sheet in the Landranger Series. The maps are in colour and have a concise legend with a list of colour-coded soil symbols and an explanation of the broad soil types occurring in each district. The map units are described in detail in an accompanying Memoir.

***Ad hoc* surveys (1985-present)**

The main commissioner of soil maps for agriculture is MAFF. Ad hoc surveys are either (1) published maps or (2) produced for particular clients at scales to suit the purpose. The maps from these surveys are produced in a limited edition, usually in monochrome by the dyeline process, or in colour by the Cromalin process. The following maps have been produced to date:

Soils of the Levels and Moors in Somerset and Avon (1:100 000 scale)
Soils of Norfolk (1:100 000 scale)
Soils of the Northumberland Hill Farming Project area (1:100 000 scale)
Soils of the North York Moors
Soils of the Chatteris District of Cambridgeshire (Sheet TL38) (1:10 000 scale on air photo mosaic base)

Soils around nuclear establishments (8 km radius)
1:50 000 scale (MAFF)
Sizewell, Suffolk (1992)
Sellafield and Drigg, Cumbria (1995)

Soils of the Nitrate Sensitive Areas (NSAs)
1:25 000 scale (MAFF)
Bourne Brook, Warwicks

Many soil maps have been produced for private clients, including farmers for land management awareness, landowners for planning permission, tenants in the rent review process, for litigation and for advising in nature conservation. Details can be obtained from the SSLRC.

Computerised data interpretation and geographical information systems

The project commissioned by the Department of the Envionment was a pilot study carried out in the Southampton area to investigate the use of digital map information as the basis for producing thematic maps based on soils data.

Key reference:
Hodgson, J M & Whitfield, W A D. 1990. Applied soil mapping for planning, development and conservation. (London: HMSO.)

The results of field investigations and laboratory analyses are stored in SSLRC's land information system - LandIS. This operates via a Relational Database Management System incorporating expert systems, automated cartography, geographical information systems, data visualisation and statistical interpretations to allow the integration and manipulation of different sources of data and output which is easily understood.

SSLRC has developed computer techniques to assess and integrate soil, climate and other environmental information at all levels. It is possible to consider the suitability from individual crops to tree species and various management techniques, risks to the environment and hydrological processes. The advent of geographical information systems (GIS) gives greater flexibility in map production over conventional cartography, particularly where single-factor and derived maps are produced.

Examples of derived maps are the paper-based Groundwater Vulnerability Maps for the National Rivers Authority (NRA) (see Figure 8) and maps of corrosion risk to buried ferrous pipes produced for the water industry.

Software for derived soil maps

User-generated maps of soil and environmental information for the whole of England and Wales can be produced by the software application SEISMIC (Spatial Environmental Information System for Modelling the Impact of Chemicals) to SSLRC data (Figure 12) in order to identify risk zones at

a national and regional level. Developed software aimed at specific applications, but with more general uses also, are the Catchment Information System (CatchIS), Information System for Underwriting Risk Evaluation (INSURE) and Land Evaluation for Corrosivity and Subsidence (LEACS).

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Soil maps SSLRC	1:250 000	1:63 360 1:50 000 1:25 000	1:25 000
Soil reports SSLRC		Memoir, Record, Bulletin, Special Survey	Record, Bulletin, Special Survey
Derived soil maps SSLRC	Land use capability	Recreational use Shrink and swell Compressible soils	Trafficability Soil corrosivity

Table 6 Types of soil information and their potential uses

6 AQUIFER DATA, including information on groundwater vulnerability and flood risk

Principal contacts for information:

Hydrogeology Group
British Geological Survey
Maclean Building
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB
Tel: 01491 838800
Fax: 01491 825338

National Groundwater Centre
Environment Agency
550 Streetbrook Road
Solihull
West Midlands B91 1QT

Water Services Association
1 Queen Anne's Gate
London SW1H 9BT
Tel: 0171 957 4518
Fax: 0171 222 5586

Institute of Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB
Tel: 01491 838800
Fax: 01491 825338

The Flood Defence Officer
Environment Agency
Rivers House
Waterside Drive
Aztec West
Almondsbury
Bristol BS12 4UD

Information in this category concerns hydrogeology and hydrology and is of crucial importance in safeguarding the nation's water resources. There is an increasing demand for more and cleaner water and to conserve and exploit it in a planned way. To do this effectively all parts of the water cycle need to be understood. In particular, knowledge of the geology and the flow of water through aquifers and other strata is essential in order to model the effects of changes in supply or demand and the movement of pollutants.

Hydrogeological maps

A range of hydrogeological maps is published by BGS at various scales from 1:625 000 to 1:25 000. They show, for example, surface water features, water quality, annual rainfall figures, areas of saline water intrusion and aquifer potential. Areas covered are shown by Figure 7. These hydrogeological maps are specialised products from which thematic maps showing selected topics such as aquifer vulnerability, acid rain susceptibility and geothermal potential can be prepared for use by non-specialists.

Hydrogeological reports

The BGS publishes a range of water supply papers under a variety of titles including well inventories, research papers, hydrogeological and technical reports. Titles are available on request from BGS.

Databases

BGS maintains the National Groundwater archive, a database of over 130 000 borehole and well records including information such as location, well type, pumping yields, standing water levels and water quality.

An aquifer properties database contains pumping test data and core analysis data (held in digital form), including information on permeability, transmissivity, porosity, and storage coefficient as well as aquifer and test details.

The Institute of Hydrology is responsible for the national Water Archive which contains data on river flow and catchment area rainfall. These data, combined with hydrogeological information, are used for a full understanding of aquifers and their recharge potential.

Environment Agency (EA) responsibilities

The Environment Agency began work on 1 April 1996. It combined the regulation of land, air and water through the merger of the National Rivers Authority (NRA), Her Majesty's Inspectorate of Pollution (HMIP), Waste Regulation Authorities (WRAs) and several units from the former Department of the Environment.

The EA is responsible for data concerning:

- water levels from monitoring boreholes
- source protection zones
- water quality
- river flow gauging information
- hydrogeological reports
- licensed ground and surface water abstractions, with information on location, site name, source, purpose, yield and name of licensee
- flood risk

Groundwater vulnerability maps

The British Geological Survey (BGS) and the Soil Survey and Land Research Centre (SSLRC) are in the process of preparing for the Environment Agency a series of 53 Groundwater Vulnerability maps to cover England and Wales at a scale of 1:100 000 (see Figure 8). The maps are published by HMSO.

The maps are designed so that planners, developers and consultants can identify the vulnerability of groundwater to contamination. This will ensure that developments conform to the EA Policy and Practice for the protection of groundwater.

The maps incorporate an assessment of the physical and chemical properties of the soil combined with hydrogeological and geological information, such as lithology and permeability characteristics, to produce a total of seven groundwater vulnerability classes. The maps will encourage better judgements to be made on the land-use

allocation, particularly where the location of new developments could impact on groundwater quality. They will also help to lessen potentially polluting activities in vulnerable areas.

A legend on each map includes information on the geological classification, the soil classification and the vulnerability classes. The easy-to-follow colour coding provides information on a given area at a glance.

Environment Agency flood risk maps

The Environment Agency (EA) has the responsibility for assessing areas prone to tidal and river flooding. Maps produced to illustrate this are Section 24 maps, although not all EA regions have published these.

The NRA aims to provide effective protection for people and property from flooding. This is achieved by the construction and maintenance of flood defences and through the provision of effective and timely flood warnings.

Flood events are described in terms of the frequency at which, on average, a certain severity of flood is exceeded. This frequency is usually expressed as a return period in years, e.g. 1 in 50 years. Different types of land-use require different levels of protection from the defences, for example people and property have a higher standard of protection than agricultural land.

Water companies

The Water Industry of England and Wales is divided into ten regional companies (e.g. Thames Water and Anglian Water), geographically based on river catchment areas, and sixteen Water Companies whose boundaries may cross river catchments. All are members of the Water Services Association which can advise on areas of responsibility and company addresses.

The water companies are responsible for the maintenance of aquifer protection policies which identify protection zones based on the nature of geological strata, and the chemical and biological sources of contamination. The allocation of zones might vary but, for example, Southern Water identifies the following:

Zone 1: for all public and some private sources of supply

Zone 2: for all aquifer outcrops (Chalk and Upper Greensand) and as a special buffer zone around Zone 1 sources located on Zones 3 and 4

Zone 3: for the more important granular aquifers

Zone 4: for the less important granular aquifers

Zone 5: for impermeable strata

Water companies also hold confidential information on abstraction quantities and aquifer properties.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Hydrogeology maps BGS	1:625 000 1:125 000 1:100 000	1:100 000 1:63 360 1:50 000	
Hydrogeology reports BGS		Water supply papers	Well inventories
Hydrogeology databases BGS			National groundwater archive borehole records
Groundwater vulnerability maps EA	1:100 000	1:100 000	
Flood risk maps EA			
Databases EA	river flow, gauging information, water quality flood risk	source protection zones, licensed abstractions flood risk	borehole water levels, hydrogeological reports

Table 7 Types of hydrogeological, vulnerability and flood risk data and their main uses

7 ENGINEERING GEOLOGY AND SITE INVESTIGATION

Principal contacts for information:

Group Manager
Coastal and Engineering Geology Group
British Geological Survey
Keyworth
Nottingham NG12 5GG

Geological Society Engineering Group
Burlington House
Piccadilly
London W1V 0JU

British Geotechnical Society
1 George Street
Westminster
London SW1P 3XB

Engineering geology is the application of geological techniques to the study of rock and soil materials. Thus knowledge of ground conditions can be interpreted in terms of the implications for planning and carrying out development. This knowledge is best presented in summary form as an engineering geology map which shows areas where rocks and soils have similar geotechnical characteristics, based on their lithology and physical properties.

The national review projects concerned with instability due to natural cavities, mining instability, landsliding and foundation conditions (see section 2) are of direct relevance to engineering geology.

Key references:
Applied Geology Limited. 1994. A review of instability due to natural underground cavities in Great Britain, 2 vols. Available from Rust Environmental, Cranford, Kenilworth Road, Blackdown, Royal Leamington Spa, Warwickshire CV32 6RG.

Arup Geotechnics. 1992. Review of Mining Instability in Great Britain, Summary Report. (London: HMSO.)

Geomorphological Services Ltd and Rendel, Palmer and Tritton. 1990. National landslides database: final report (2 vols). Unpublished. Can be consulted, by prior arrangement, at the Department of the Environment, Transport and the Regions, Eland House, Bressenden Place, London SW1E 5DU.

Wimpey Environmental Limited and National House Building Council. 1995. Foundation conditions in Great Britain: a guide for planners and developers, Summary Report. (Hayes, Middlesex: Wimpey Environmental Ltd.) Available from Hargreaves Road, Swindon, Wiltshire SN2 5AZ.

Engineering geology maps and reports

These have been produced mainly to accompany applied geology mapping projects (see section 3) and some BGS internal Open File Reports. Most are colour printed at 1:50 000 or 1:25 000 scale; early projects produced black and white dyeline prints.

Typically engineering geology maps are produced for the superficial deposits (with or without artificial deposits), and the solid or bedrock strata, either separately or combined. On BGS maps an accompanying table describes each geotechnical unit in terms of lithological characteristics, type of foundations which will be suitable, ease of excavation, use of spoil in engineered fill and stability of cut slopes.

A series of BGS reports covering the engineering properties of major British geological formations is currently being undertaken. The formations being studied are the Gault, Mercia Mudstone, and Lambeth Group (Woolwich and Reading beds). Information on these can be obtained from the Coastal and Engineering Geology Group, BGS.

Engineering geology databases

BGS holds over 19 000 site investigation reports, many of which contain geotechnical details from in situ and sample testing. In areas where applied geological mapping projects have been carried out (Figure 1) much of the SI information has been incorporated into databases.

Other sources of engineering geology and site investigation data

Major engineering consultancies, local authorities and site investigation companies hold organised databases of borehole records; others may hold uncollated information. BGS routinely collects this information in current areas of work and is routinely supplied with it from many sources. Advice on local sources can be gained by enquiring to local planning officers and building control departments.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Engineering geology maps BGS Applied geological mapping contracts (see section 3)	1:50 000 1:250 000	1:25 000	1:10 000
Engineering geology reports BGS		Technical report	Technical report
Engineering geology databases BGS		Borehole records Geotechnical data	Borehole records Geotechnical data
Site investigations Consultants Local authorities Site investigation companies		Borehole records Geotechnical data	Borehole records Geotechnical data

Table 8 Types of engineering geology information and their main uses

8 MINERAL RESOURCES DATA

Principal contacts for information:

Minerals, Environment and Geochemical Surveys Division
British Geological Survey
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3100
Fax: 0115 936 3200

Department of the Environment, Transport and the Regions
Minerals & Waste Planning Division
Zone 4/A2
Eland House
Bressenden Place
London SW1E 5DU

The Coal Authority
Bretby Buisiness Park
Ashby Road
Burton-on-Trent
Staffordshire DE15 0QD
Tel: 01283 553291
Fax: 01283 553251

Mineral Planning Authorities

Most commonly, potential users of minerals information want to know where the current and former workings are, where resources occur, and hence where future workings may take place. Coal mining is discussed separately below.

Competition and conflict between different use of land is increasing, notably in the field of minerals extraction. Achieving the right balance between the protection of the environment and wealth creation through the development of indigenous mineral resources is one of the major issues facing the minerals industry and the planning process today. This balance will help to ensure that important mineral resources are not needlessly sterilised by other forms of development, but safeguarded for the future. It is important, therefore, that the location, extent, quality and economic potential of mineral resources are known. Understanding the value of the resource is also essential in resource management as decision makers need some measure of relative value in order to make rational choices.

In the planning and implementation of development projects information will be required on:

- the nature and extent of mineral resources in order to prevent sterilisation
- potential sources of minerals, particularly construction minerals, for use in the development
- the nature, location and extent of former mineral workings which may present a hazard to the development.

The availability of information on mineral resources is unevenly distributed throughout the country and its quality, and therefore reliability, is variable. Moreover, the identification and delineation of mineral resources is inevitably somewhat imprecise. It is limited not only by the quantity and quality of information currently available but also may involve taking a view on what might, or might not, become economic to work in the future.

Mineral resources

There are two key sources, BGS and the Local Authorities. BGS produces a range of geological maps which depict deposits used as a source of minerals. More useful to the non-geologist are special maps and reports on mineral resources.

The Mineral Planning Authority is required to produce a local plan which identifies areas of future mineral working and may or may not show the distribution of the resource.

The degree of geological knowledge about a mineral resource may range from speculation about its existence through to a detailed evaluation of the quantity and quality of material available for extraction. **Identified** mineral resources are commonly divided into three categories - **inferred**, **indicated** and **measured** - depending on the degree of geological knowledge available on their extent and nature.

Inferred resources are defined from available geological information, primarily the geological map and related reports such as memoirs. However, the interpretation of mineral resource potential from the geological map may be difficult, at least without specialist advice. The main sources of information are as follows:

Thematic maps of mineral resources in the output from applied geological mapping projects carried out by BGS and others (see Figure 1 for the location of these projects).

A series of reports and accompanying 1:100 000 maps, currently in preparation. When completed, they will cover all administrative areas of England and Wales. These maps, which are available in digital form, also show the location of current mineral workings and the extent of mineral planning permissions. Information on their availability can be obtained from BGS, Keyworth.

Key reference:
British Geological Survey. 1995. Mineral Resource Information for development plans. Staffordshire: resources and constraints. British Geological Survey Technical Report WF/95/5. (Keyworth: British Geological Survey.)

Indicated resources are those which have been defined by drilling and sampling on a regular basis and have had their technical properties characterised.

BGS has produced a series of Mineral Assessment Reports, with included 1:25 000 or 1:50 000 scale multitone monochrome maps, for many areas of the UK. The majority of these describe the sand and gravel resources, the rest describe other bulk or industrial minerals including conglomerate, hard rock aggregate, limestone and celestite (Figure 13). BGS has also issued reports and accompanying maps on the assessment of bulk minerals in its technical report series, mostly on sand and gravel (Figure 14).

Over 150 reports and data releases have been issued by the BGS following a metalliferous Mineral Reconnaissance Programme of the UK, funded by the Department of Trade and Industry. They include maps of parts of northern and western Britain recording geological, geochemical, geophysical and metallogenic information (Figure 15).

Measured resources are determined usually by closely-spaced drilling, together with an evaluation of the quality of the material, its market suitability, the revenue its sale will generate and ultimately the economic viability of the deposit.

Active mineral workings

Mineral Planning Authorities usually keep records of current mineral workings and such information is therefore readily available to local planners.

Basic information on the location, name, ownership of mineral workings, the mineral worked and its geology may be derived from the BGS Mines and Quarries database, known as 'Britpits'. It can be found in the BGS Directory of Mines and Quarries which is published periodically. It gives the name, location, ownership, basic geology and commodity produced for all onshore mineral workings. This information in digital form is also being integrated by BGS into a national GIS-based minerals information system called MINGOL (Minerals GIS On-line) which includes physical and chemical characteristics of the minerals and their accessibility to markets.

The latest Ordnance Survey maps at 1:10 000, or the larger 1:1 250 or 1:2 500 scales, may show the current extent of workings but this would need to be confirmed on the ground. In the absence of suitable maps, recent aerial photographs often clearly show the whereabouts of existing quarries and pits. Neither maps nor photographs indicate whether a working is active or not, and small concerns may open and close periodically as demand fluctuates.

Former mineral workings

Mineral workings that are still open, and those only recently backfilled, should be easy to locate from maps and aerial photographs. Information on these and others may be available in Local Authority records, records of existing mineral extraction companies and old mineral planning permissions.

Recent 1:10 000 scale BGS geological maps and derived applied thematic maps show all known areas of worked ground (of which some may still be active workings) and areas of worked and made ground (or backfilled workings). Earlier 1:10 560 scale maps usually recorded the presence of extant quarries but were less systematic in mapping those areas that had been backfilled.

Geological memoirs and the records of local natural history societies are additional source of information about former workings.

Key reference:
Arup Geotechnics. 1992. Review of Mining Instability in Great Britain, Summary Report. (London: HMSO.)

Coal mining

In addition to the above there is a wealth of information especially on coal and related topics, notably the effects of coal mining.

There have been several applied geology mapping projects in both current and former coal mining areas such as St Helens, Leeds, the Black Country, Stoke-on-Trent, Wigan and Bradford (see section 2). These give a good idea of the types of mining, the available information and the range of factors that need to be considered when undertaking development in coal mining areas.

Coal has been worked in Britain probably since Roman times. Initially the exposed and near surface seams were worked by surface diggings which were gradually deepened by the use of bell pits and shallow tunnels. Throughout the 19th century deep mines were developed to exploit coal from the concealed coalfield and power the industrial revolution.

Records of the early mines are often sketchy or non existent and great care must be taken when developments are proposed in a coalfield area. When nationalisation of the coal industry took place in 1947 most private mines were replaced by a single body, the National Coal Board, and later British Coal, which has kept more systematic records. In 1994 with the privatisation of the coal industry most of British Coal's responsibilities were transferred to the Coal Authority (CA) which now owns the nation's coal and licenses its extraction. It holds plans for current, future and abandoned mines, mining reports, as well as information on subsidence and geological data.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Former mineral workings BGS Coal Authority Local Authorities	Previous Directory of Mines and Quarries, Previous Regional Plans, Coal Authority mine abandonment plans, Arup report for DOE on mining instability	Previous Local Authority Plans, Ordnance Survey 1:63 360, 1:50 000 and 1:25 000 maps, BGS 1:50 000 maps and memoirs, Coal Authority mine abandonment plans, Arup report for DOE on mining instability	Ordnance Survey 1:10 000, 1:2500 and 1:1250 scale maps and plans, BGS 1:10 560 maps (and field maps) and field notebooks, aerial photographs, published literature on industrial heritage, Coal Authority mine abandonment plans, Arup report for DOE on mining instability
Current/Active mineral workings BGS Local Authorities planning departments	Directory of Mines and Quarries, Regional Plans	Local Authority Plans, Ordnance Survey 1:50 000 and 1:25 000 maps, BGS 1:50 000 maps and memoirs, Coal Authority mine plans	Ordnance Survey 1:10 000, 1:2500 and 1: 1250 maps and plans, BGS 1:10 000 maps and technical reports, Aerial Photographs, Coal Authority mine plans
Mineral Resources and future mineral workings Mineral Planning Authorites	Regional Plans, Sub-Regional plans, Development plans, Minerals/Local Subject plans, County Structure plans, County Minerals plans	Minerals/Local Subject plans, County Structure plans, County Minerals plans, BGS Mineral Assessment Reports with 1:25 000 maps, Coal Authority proposed mining plans	Minerals/Local Subject plans, BGS 1:10 000 maps and technical reports, Coal Authority proposed mining plans

Table 9 Types of minerals data and their main uses

9 GEOCHEMISTRY OF WATER AND SOILS

Principal contacts for information:

Environment Agency
Head Office
30 Albert Embankment
London SE1 7TL
Tel: 0171 820 0101

National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ

Minerals, Environment and Geochemical Surveys Division
British Geological Survey
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3100
Fax: 0115 936 3200

Building Research Establishment
Building Research Station
Garston
Watford WD2 7JR
Tel: 01923 894040
Fax: 01923 664010

Environmental protection

Geochemical information is required for environmental protection purposes to aid the assessment of contaminated land and the disposal of hazardous waste. Geochemical data can provide essential information towards the investigation and remediation of past and present industrial sites and aid the planning process for the development of new sites. Geochemistry also helps to assess the chemical composition of wastes in landfill sites, leachates and the suitability of sites for future landfill development. In order to collect information on the source and dispersion of a wide range of heavy metals, toxic elements and organic compounds it is necessary to sample and analyse soils, stream sediments, surface waters, groundwaters, superficial deposits and air.

These investigations require, for the most part, site specific geochemical surveys which will be undertaken by those with expertise in sampling, sample preparation, analysis and data interpretation.

In areas of water abstraction and storage, the Environment Agency may hold information from the monitoring of groundwater composition.

Stream sediment and surface water data

The British Geological Survey (BGS) through its national **Geochemical Baseline Survey of the Environment (G-BASE)** is providing a database on the occurrence and distribution of a wide range of chemical elements for a variety of economic and environmental applications. The survey is based on the collection and analysis of stream sediments at a density of 1 sample per 1.5 km^2 and surface waters at an average density of 1 per 3 km^2. The sampling, preparation and analysis of the samples is undertaken following strict quality control procedures to standards set by the UN sponsored International Geological Correlation Programme No 360 - Global Geochemical Baselines. Data is currently available for much of Northern Britain and Wales (Figure 16) for 35 elements inorganic elements and is published in the BGS Geochemical Atlas Series.

The **Wolfson Geochemical Atlas** of England and Wales is based on the collection of stream sediments at a density of one sample per 2.5 km^2 (Webb and others, 1978). The distribution of 21 elements is illustrated and includes key environmental elements such as lead, copper, zinc, cadmium and arsenic.

Baseline geochemical data can aid the assessment of contaminated areas by establishing the natural background which may vary greatly depending on the underlying geology, the presence of metallic mineralisation and climatic and morphylogical influences. These data are particularly useful when attempting to apply current guidance trigger levels to contaminated sites and can help to establish the extent of remediation necessary to restore the site to natural baseline conditions. This is particularly important in areas of the UK where there is a natural enhancement of Potentially Harmful Elements (PHEs) such as lead, copper, zinc, arsenic and cadmium due to geological processes. In such cases it may not be realistic to impose the same remediation strategy as would be applied to areas with a lower natural distribution of PHEs.

BGS has produced a **Potentially Harmful Element Map**, and accompanying report, for the British Isles. The map illustrates the extent of areas with above background concentrations of five selected elements; lead, copper, zinc, arsenic and cadmium (Appleton,1995). The maps provide a useful guide to areas of elevated PHEs which have relevance to planning and development.

The Environment Agency and local authority environmental health officers will be able to advise about many contaminants. The EA also has geochemical data on surface water quality as part of the river catchment management programme.

Key references:
Webb, J S, Thornton, I, Thompson, M, Howarth, R J & Lowenstein, P L. 1978. The Wolfson geochemical Atlas of England and Wales. (Oxford: Oxford University Press.)

Appleton, J. D. 1995. Potentially Harmful Elements from natural sources and mining areas: characteristics, extent and relevance to planning in Great Britain. BGS Technical Report WP/95/3. (Keyworth: British Geological Survey.)

Soil geochemical data

The Soil Geochemical Atlas of England and Wales (McGrath and Loveland, 1990) is based on the collection of soils at a density of 1 sample per 5 km^2. A total of 5692 samples were collected for England and Wales but much of the urban areas were not sampled with the exception of large open spaces such as parks. The project was undertaken by the Soil Survey of England and Wales and the Soil Science Department of Rothamsted Experimental Station. The topsoil (0-15 cm) minus 2 mm fraction was analysed for 18 elements including cadmium, copper, chromium, nickel, lead and zinc.

Key reference:
McGrath, S P & Loveland, P J. 1992. The Soil Geochemical Atlas of England and Wales. (Blackie Academic and Professional.)

Radon potential

Radon is a naturally occurring radioactive gas. It is produced by the decay of both uranium and thorium. Historically radon was thought to be health giving but it is known to be a major contributor to the radiation dose received by the human body. The National Radiological Protection Board (NRPB) has shown that at least 50% of the total dose for the average citizen is from combined radon and thorium (Clarke and Southwood, 1989).

Radon gas can be potentially harmful to health where high levels are present in buildings or mines. The NRPB has set the action level for existing homes at an average radon level of 200 Bq/m^3 measured over a year. Above this level remedial action is recommended. Advice on radon affected areas is given by the NRPB. The implications of such areas for construction of buildings is dealt with by the Building Research Establishment (BRE).

The radon potential of an area is determined by the composition of the underlying rocks and superficial deposits. BGS has carried out an assessment of radon and background radioactivity from natural sources (Appleton and Ball, 1995).

Parts of the country are classed as **'radon affected areas'**. These are where 1% or more properties have radon above the designated action level of 200 Bq/m^3. It is a requirement that new homes in these areas are built with precautions against radon ingress. These measures, which are usually relatively simple, consist of including a membrane in the construction with good underfloor ventilation, possibly fan assisted, to vent radon to the outside. Advice about the areas can be obtained from BGS and the NRPB. The NRPB provides a free service to householders to monitor radon levels in properties.

Key references:
Clarke, R H & Southwood, T R E. 1989. Risks from ionising radiation. Nature, 338, 197-198.

Appleton, J D & Ball, T K. 1995. Radon and background radioactivity from natural sources: characteristics, extent and relevance to planning in Great Britain. BGS Techinical Report WP/95/2.

TYPES OF INFORMATION AND MAIN SOURCE	REGIONAL SCALE	LOCAL SCALE	SITE SPECIFIC SCALE
Site specific geochemistry **BGS**		Consultants BGS	Consultants BGS
Baseline geochemistry **BGS**	BGS Geochemical Atlas Wolfson Geochemical Atlas	BGS Geochemical Data	
Soil geochemistry **BGS, SSLRC**	Soil geochemical Atlas of England and Wales	Consultants SSLRC	Consultants SSLRC
Water geochemistry **EA**	BGS Hydogeochemical Data	Consultants EA	Consultants EA
Radon **NRPB**	DoE National Review BGS NERS Survey	DoE National Review BGS Radon Potential Maps	BGS Soil Gas Surveys

Table 10 Sources and potential uses of geochemical information

10 GEOPHYSICAL INVESTIGATION

Principal contacts for information:

Global Seismology and Geomagnetism Group
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA

Regional Geophysics Group
British Geological Survey
Keyworth
Nottingham NG12 5GG

The principal use of geophysics in major development initiatives is in site specific investigations where, increasingly, information from seismic reflection, electrical resistivity and ground radar surveys are being used.

For some specialised engineering structures the possibility of earthquakes may need to be taken in to account, and there may occasionally be a need for other geophysical information, such as gravity data and aeromagnetic data, relating to the deep geological structure.

Geophysical investigations are normally carried out by a specialist organisation. The aim of the geophysical survey is to locate some form of subsurface anomaly where the materials have markedly different physical properties. Once determined, these anomalies are usually checked by borehole drilling. Geophysical surveys may also be used to determine soil and rock characteristics. Geophysical techniques in site investigation have been used successfully in the search for suspected mine shafts, unknown cavities, tracing lateral contacts between sand and clay and estimating rock fracturing.

Seismic risk

Key references:
Preliminary study of UK seismic hazard and risk. Ove Arup & Partners, 1991.
Earthquake hazard and risk in the UK. 1993. (London: HMSO.)

The UK is in an area of low seismicity, with around 400 earthquakes located each year. Of these about 30 may be strong enough to be felt by people, and one causing damage can be expected every decade. For example, the 1884 Colchester earthquake (magnitude 4.7 on the Richter scale) damaged some 1200 buildings.

It is recognised that the hazard posed by such events needs to be assessed and taken in to account in the design of certain buildings such as power stations, refineries and chemical works where the direct cost of failure or the ensuing consequences could be high. For such structures a detailed risk assessment of the site may need to be carried out which takes into account all the relevant factors of seismicity, geology and building design.

The Global Seismology and Geomagnetism Group of BGS monitors all seismic activity around the UK and has produced a 1:1 500 000 scale map showing the distribution of earthquakes from 1980-1994.

The report by Ove Arup (see above) should be consulted in order to gain a proper perspective of earthquake causes and effects, building vulnerability, hazard assessment, seismic risks and costs. There is an accompanying technical report which discusses the effects of local soil conditions, mining induced seismicity, liquefaction and other aspects in greater detail. It also refers to the Oasys UKCAT, a PC based catalogue of recorded earthquakes since 1000 AD.

Geophysical information map

BGS provides regional geophysical information maps (GIM), available as plot-on-demand products with a coverage based on the 1:50 000 scale geological map sheets in the UK (see Figure 3). These GIMs summarise graphically the publicly available geophysical data held in BGS digital databases:

Regional gravity data: Bouguer anomaly contours and location of observations,
Regional aeromagnetic data: total field anomaly contours and location of digitised data points along flight lines,
Gravity and magnetic fields plotted on the same base map at 1:50 000 scale,
Separate colour contour plots of gravity and magnetic fields at 1:250 000 scale,
Location of geophysical surveys,
Location of public domain seismic reflection and refraction surveys,
Location of deep boreholes and those with geophysical logs

Small-scale maps of gravity anomalies (1:1 000 000) and aeromagnetic anomalies (1:625 000) are available for Britain as north and south sheets.

Geophysical site investigation

Geophysical techniques, notably seismic reflection surveys, have long been familiar to the petroleum industry and exploration companies. They have made it possible to study large areas of ground relatively quickly and cheaply, and have allowed the geological structure at depth to be determined with some confidence.

Recently these techniques have been adapted to investigate the near surface geology for site investigation purposes. These are potentially valuable in detecting underground cavities, for example solution hollows or old mine shafts. New techniques such as those involving ground penetrating radar have also been developed.

Geophysical borehole logging

Geophysical logging of boreholes has long been used by the petroleum exploration companies to aid the interpretation of deep boreholes. The techniques are being used increasingly for relatively shallow boreholes for water wells, mineral exploration and site investigation. In favourable strata they enable an interpretation to be made of the geological sequence without the necessity to recover core. Specialist advice is required on the applicability of such techniques.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Aeromagnetic data BGS	1:250 000 maps		
Gravity data BGS	1:625 000 and 1:250 000 maps		
Seismic risk data BGS Ove Arup	BGS Earthquake map Oasys programme	Ove Arup report on seismic hazard in UK	Site assessment Ove Arup Technical Report Consultants
Other geophysical information BGS	GIM	GIM	GIM
Geophysical site investigation			Consultants
Geophysical borehole logging			Consultants

Table 11 Types of geophysical information and their main uses

11 REMOTE SENSING

Every type of remotely sensed data has a potential role in the planning of major development initiatives. Satellite optical data provide a synoptic view of a large region, the interpretation of which is most useful in linear projects, such as roads or rail links, or large areas. Aerial photography is more useful in site-specific studies.

Principal contacts for information:

Most county councils and unitary authorities periodically have their whole region systematically covered by aerial photography, commonly in colour and at 1:10 000 scale. These can often be examined at council offices or planning departments. Other organisations such as the Environment Agency regional offices (formerly the NRA regional offices) may have air photograph coverage.

There are numerous other sources of photographs and these may be listed in the National Association of Air Photo Libraries **(NAPLIB)** Directory of Aerial Photographic Collections in the United Kingdom, 1993 (ISBN 085142 304 3). Details of coverage can be obtained from:

Air Photo Cover Group
Ordnance Survey
Romsey Road
Maybush
Southampton SO9 4DH

The Air Photographs Officer
Air Photographs Unit
Department of the Environment, Transport and the Regions
Room 932
Lambeth Bridge House
Albert Embankment
London SE1 7SB

The Air Photographs Officer
Welsh Office
Room G-003 Crown Offices
Cathays Park
Cardiff CF1 3NQ

Air Photographs Unit
Scottish Development Department
Room 1/21 New St Andrews House
St James Centre
Edinburgh EH1 3SZ

The Air Photograph Units may be able to supply RAF photographs from about 1945 and Ordnance Survey photographs up to 1969. They also operate the Central Registers of Air Photography for photographs held by commercial air photography companies such as Aerofilms Ltd.

Other sources are the National Remote Sensing Centre, ADAS, and the Royal Commission on the Historic Monuments of England.

Customer Services
National Remote Sensing Centre
Delta House, Southwood Crescent
Southwood, Farnborough
Hampshire GU14 0NL
Tel: 01252 541464
Fax: 01252 375016

ADAS
Aerial Photography
Brooklands Avenue
Cambridge CB2 2DR
Tel 01223 455780

Information on the coverage of the different types of satellite imagery, and digital or photographic copies of the images are available from the National Remote Sensing Centre (see above).

Remotely sensed data can be acquired from two types of platform, aircraft and satellites. Four broad types of data are commonly available: photography, optical scanner imagery, thermal images and radar data. All these data types may be of relevance in planning and development.

A comparison of airborne and satellite data

Satellite imagery and aerial photographs can both be used to obtain Digital Terrain Models and interpretations of geomorphology, solid and superficial geology, soils, engineering ground conditions, land use and hydrological information.

Aquisition of aerial photographs can be made at a particular time of day or in a certain season. Bad weather can be avoided, the ground resolution can be varied by changing the flying height and the type of sensor can be selected easily. Certain types of data, such as thermal infrared imagery, imaging spectrometry data and data of the highest spatial resolution are only available from airborne sensors. The disadvantage of acquiring data from an aircraft is the poor geometric quality of the data acquired. Aircraft imagery is often subject to two types of distortion; the large viewing-angle required to image a reasonable area from low altitude means that a certain amount of predictable distortion is inherent in the data; and the platform is unstable in all but the most perfect weather conditions, resulting in further unpredictable distortions.

Satellite images have significantly better geometric quality than airborne images. The data are acquired from very high altitude, so that a small viewing angle can be used to image a large area, providing a single internally-consistent data set covering a whole region. In addition, the satellite orbits above the main weather systems of the Earth's atmosphere and is therefore very stable. These two factors greatly reduce the inherent distortions in the imagery. Consequently, satellite imagery can readily be corrected to a map system such as British National Grid. On the negative side, the configuration of the sensor, ground resolution and acquisition dates and times are all pre-determined. If there is bad weather coincident with the satellite overpass, an optical or thermal image may contain 100% cloud cover so that the target is not imaged at all.

Aerial and space photography

Aerial photography can be acquired at a range of scales depending on flying height, the most common lying between 1:10 000 and 1:50 000.

Because of the very high spatial resolution of photographic prints, an experienced interpreter can extract detailed information from even small-scale photographs. Black and white, colour and colour infrared photography all have uses in earth science. In general it is possible to distinguish more variations in colour than in grey tone, so that colour photographs allow better discrimination of different soil and rock types and are preferred by earth scientists. Infrared photography is less affected by atmospheric haze than colour photography and can allow clearer discrimination of different vegetation types and soil moisture variations. All these options represent very limited spectral resolution in comparison to other types of remotely sensed data.

There are two principal sources for space-borne photography, the American Space Shuttle and Russian satellite photography. The Space Shuttle crew take hand-held photography of various sites around the shuttle's orbit, typically producing non-vertical photographs covering very large regions which will not be relevant to development projects. Of more relevance is Russian satellite photography, now widely available and ranging in ground resolution from 3 m to 30 m, which can be used at scales up to 1:5 000.

Optical data

Optical data must be processed on an image analysis system before being interpreted by the earth scientist.

The most widely used optical data are acquired by the American Landsat Thematic Mapper (TM) sensor and its French rival SPOT. In addition, Indian and Russian satellite imagery is now available for some areas and the Japanese satellite JERS-1 acquired some good imagery in the 18 months it was fully operational from 1992-93. Several new commercial satellite systems, some with 1 m spatial resolution and stereo capabilities, will be launched during 1997. Sensors with many more wavelength bands are also scheduled fro launch before the millenium. At present these imaging spectrometers are only flown on aircraft. In some geological projects airborne scanner data may thus provide more information than satellite imagery.

Landsat data

The American Landsat carries two main instruments, the Multi Spectral Scanner (MSS) and the Thematic Mapper (TM). The MSS has coarse 80 m spatial resolution and limited spectral bands; three bands corresponding to blue, green and red visible light and a single band in the near infrared. A full scene in digital format costs as little as £250.

The limited resolution of the MSS sensor in comparison to TM make it suitable for only regional geological studies and where data from before 1984 are required, perhaps to look at historical land use for a development site. The more recent TM instrument has improved 30 m ground resolution and better spectral resolution, measuring reflected radiation in six wavelength bands: three in the visible; one in the near infrared; and two in the shortwave infrared. It also records emitted radiation for a single band in the thermal infrared at a coarser ground resolution of 120 m. TM data can be used at scales of up to 1:50 000, each image covers 185 km x 185 km and images are repeatedly acquired every 16 days. A full 7 band TM scene in digital form costs about £3500 and a photographic print a few hundred pounds depending on the scale and area.

For the UK already-processed high quality Landsat TM images digitally registered to the National Grid are available from:

Remote Sensing Group
British Geological Survey
Keyworth
Nottingham NG12 5GG

SPOT data

In comparison to Landsat TM, the sensors on board the French satellite SPOT have improved ground resolution and a stereo capability but reduced spectral coverage. The Panchromatic sensor (PAN) has 10 m ground resolution for a single band in the visible wavelengths and can be used at scales up to 1:10 000. The multi spectral sensor (XS) has 20 m ground resolution for three spectral bands, two in the visible and one in the near infrared wavelength region. Both types of data cover an area of 60 km x 60 km per scene. For an extra charge the satellite can be programmed to acquire an image at a particular time. The stereo capability allows the production of DTMs with a coarse 10 m resolution.

Indian, Russian and Japanese satellite data

The Indian IRS series of satellite sensors produce data with similar spectral resolution to TM bands 1-4, but with increased ground resolution of up to 5 m. Data from these sensors are now commercially available in hard copy or digital format, as are various types of Russian satellite data. Some of the Russian data sets have 5 m ground resolution, but the spectral range is limited; the high spatial resolution sensors only have a single spectral band and the lower resolution sensors have two bands in the visible and a single band in the near infrared wavelength region.

The Japanese JERS-1 sensor has 8 bands comprising equivalents of Landsat TM2, TM3, TM4 (2 bands to give stereo), TM5, and 3 bands covering the wavelength range of Landsat's single band TM7. This increased resolution in the shortwave infrared wavelength region, where clay, sulphate and carbonate minerals have diagnostic absorption features, offers the potential for increased discrimination of exposed rocks and soils.

Airborne scanner data

Two instruments are available in the UK, the Daedalus Airborne Thematic Mapper (ATM) and the Compact Airborne Spectrographic Imager (CASI), both owned and operated by the Natural Environment Research Council.

The ATM has a similar spectral range to Landsat TM, but can be flown to acquire data at variable ground resolutions down to 1 m.

Similar instruments are available in other parts of the world. In addition, higher resolution imaging spectrometers such as NASA's Airborne Visible Infrared Imaging Spectrometer (AVIRIS), which measures 224 band spectra for every pixel in a full scene, are increasingly becoming available; Geophysical and Environmental Research Corporation's GER64 scanner with 64 bands is an example of a commercially available system. These instruments provide very detailed spectral information, but the data can be difficult to process and analyse due to the large data volumes involved.

Thermal data

Thermal data varies with temperature and is therefore useful in mapping variations in moisture content which can be related to geology, soils, spring lines, pollution and leaks from pipelines.

One airborne instrument is available in the UK, the Daedalus Thermal Line Scanner (TLS) owned and operated by Engineering Surveys Ltd. The TLS measures emitted radiation across a single broad band in the thermal infrared wavelength region. Again, ground resolution and area covered are variable depending on flying height. Similar instruments are available worldwide, and thermal sensors with several bands have been developed, such as NASA's Thermal Infrared Multi spectral Scanner (TIMS).

Radar data

Radar data are particularly useful in areas where cloud cover is a problem as their acquisition is unaffected by weather conditions. They provide information on moisture content, surface roughness and topography which can be used to map geology and soils, and produce detailed DTMs.

There are four operational satellite-based synthetic aperture radar (SAR) sensors; the European ERS-1 and ERS-2, the Japanese JERS-1 and the Canadian radar satellite, Radarsat. Radar sensors are also flown on aircraft, the main commercial system being operated by Intera who have built up a catalogue of data worldwide. Intera radar data are most useful in regions where continual cloud cover prohibits the successful acquisition of optical data or photography.

ERS-1 and ERS-2 data

These European experimental satellites acquire SAR data with a ground resolution of approximately 30 m in images which measure 100 km x 100 km. The incidence angle of the SAR instrument is 23°. It leads to distortion effects in mountainous terrain, but is ideal for lowland terrain and coastal areas. The concurrent operation of both sensors means that stereo pairs of radar images can be obtained.

JERS-1 data

The Japanese JERS-1 satellite also carries a SAR sensor, the main advantage of which is an improved incidence angle of 35°.

Radarsat

The principal advantage of the Canadian Radarsat sensor is the ability to vary the incidence angle of the SAR instrument. This allows data to be tailored to a particular geological environment or problem. Other positive features of this new satellite are the provision of stereo image pairs and the choice of ground resolution and image area. The best resolution data have 10 m pixels.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Aerial Photography Public collections Surveying companies	1:50 000	1:10 000 1:25 000	1:5 000
Satellite imagery NRSC BGS	Landsat Radarsat	SPOT ERS-1 IRS Radarsat	new sensors due for launch in 1997
Airborne Scanner NERC Engineering Surveys			Daedalus ATM Daedalus TLS

Table 12 Types of remotely sensed data and their main uses

12 HISTORICAL EVENTS

Man-made and natural events in the historical record are related to the Earth Sciences, and may be relevant to major developments. They may be ephemeral or catastrophic events which were sufficiently newsworthy to be reported in the local or national newspapers. County, Borough and Town and Parish Council Records, directories and diaries in public record offices and libraries may contain useful information. Some examples of this type of event are given below.

Key reference:
The National Review Project on Erosion Deposition and Flooding carried out for the DoE includes an "Archive of Significant Events", gleaned from published accounts, in three volumes: Volume 1, 1950 to 1993; Volume 2, 1900 to 1950; Volume 3, 1950 to 1993. It can be consulted by prior arrangement at the Department of Environment, Transport and the Regions, Eland House, Bressenden Place, London SW1E 5DY.

Examples of man-made events that impact on development

- Mining subsidence
- Collapse of mine shafts or wells
- Gas explosions at mine workings or landfill sites
- Bomb craters and unexploded bombs and shells
- Landslides caused by excavations
- Collapse of open excavations, dams and tunnels
- Embankment failure
- Old waste tips

Examples of natural events that impact on development

- Coastal and river flooding
- Landslides
- Coastal and river erosion
- Collapse of ground into solution hollows

The range of natural processes

There is a large variation in the normal range of many natural processes, best typified by rainfall patterns. At one extreme there may be several months of drought, at the other catastrophic flash floods rated as perhaps 1 in 250 year events. Historical records which provide further evidence of this variation are very useful in helping to determine the extreme range of events which need to be catered for in the design of any development.

13 INFORMATION ON SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE

Environmental considerations in the planning of new development are increasingly concerned with the conservation of sites which may be important because of their geological characteristics. For example, a disused quarry originally worked for minerals may be invaded by rare plants and be granted SSSI status.

Invariably the geology and geomorphology has played a large part in the origin of particular sensitive ecological environments which need protection. A proper understanding of a site's geological setting will help to facilitate the granting of protection.

Sites of environmental significance range in importance from international sites (World Heritage Site, Ramsar Site and Special Protection Area) to national sites (National Nature Reserve (NNR), Marine Nature Reserve (MNR), Site of Special Scientific Interest (SSSI) and Environmentally Sensitive Area) and local sites (Local Nature Reserves (LNRs)). There are about 1500 SSSIs scheduled wholly or partly on account of their geological importance and in addition 3400 Regionally Important Geological and Geomorphological Sites (RIGS) have been identified although they do not have statutory status. Other conservation categories are areas of important landscape such as National Parks, Areas of Outstanding Natural Beauty (AONB), Heritage Coasts, Country Parks, High Landscape Value Area, Green Belt and National Trust Land.

English Nature

English Nature has published a series of 47 county maps in colour at 1:150 000 scale of Sites of Special Scientific Interest and other statutory sites. In addition to SSSIs, as notified under the Wildlife and Countryside Act of 1981, these maps show NNRs, LNRs and MNRs within each county. The simplified topographic base is provided by AA Automaps superimposed on an Ordnance Survey National Grid at 10 km spacing. The sole distributor is:

Heffers Map Shops
Level Two, Rustat House
61 Clifton Road
Cambridge CB1 4GY
Tel: 01223 568417
Fax: 01223 568416

The boundary data are also available in digital formats from the agents:

MR-Data Graphics
Dukes Way
Teesside Industrial Estate
Thornaby
Cleveland TS17 9LT
Tel: 01642 750515

Some SSSIs have been set up specifically to preserve classic exposures of various geological formations.

Institute of Terrestrial Ecology

The Biological Records Centre (BRC) has developed a computerised database incorporating information on biodiversity in the UK, and is therefore a key source of baseline data for monitoring of sites and species, and their change through time. Further information is available from:

Biological Records Centre
Institute of Terrestrial Ecology
Monks Wood
Abbots Rippon
Huntingdon PE17 2LS
Tel: 01487 773381

Scheduled Monuments

Information relating to scheduled monuments under the Ancient Monuments and Archaeological Areas Act 1979 may be obtained from Local Authorities or:

English Heritage Records Office
Fortress House
23 Savile Row
London W1X 2HE

Welsh Historic Monuments
Executive Agency
Brunel House
9th Floor
2 Fitzalan Road
Cardiff CF2 1UY

14 LAND-USE

Land Utilisation Surveys of Britain

The first Land Utilisation Survey of Britain was carried out in the 1930s under the directorship of L Dudley Stamp and published maps at 1:63 360 scale.

In 1960 the second survey was initiated and is now almost complete for England and Wales and the results have been published at 1:25 000 scale. Each map covers an area of 10 x 20 km, using the Ordnance Survey 1:25 000 topographic base. Sixty-four land use categories are recognised within the following groups:

- settlement (residential and commercial)
- industry (extractive industry and active landfill mapped separately)
- transport
- derelict land (including abandoned landfills)
- open spaces
- grass
- arable
- market gardens
- orchards
- woodlands
- heath land
- moorland and rough land
- water and marsh
- unvegetated land

The field survey was originally conducted at a scale of 1:10 560, later metricating to 1:10 000, and copies of the field slips are available as photographic slides.

The published maps, an index map, and the Land Use Survey Handbook (Coleman and Maggs, 1965) explaining the principles and methodology is available from:

The Director
King's College
Strand
London WC2

Edward Stanford Ltd
12-14 Long Acre
London
WC2 E9LP

CORINE Land Cover

A programme to gather consistent information, from satellite imagery, on the state of the environment and natural resources across the European Community has produced a database of land cover at 1:100 000 scale. The main levels of information are:

- artificial surfaces
- agricultural areas
- forests and semi-natural areas
- wetlands and water bodies

The boundaries have been digitised and are available as ARC-INFO datasets for GIS applications. Maps, statistics and datasets are available from:

The European Environment Agency Task Force DGX1
Commission of the European Communities
Rue de la Loi 200 1049
Brussels
Belgium

Countryside Information System (CIS)

CIS has been developed to provide information for each 1 km grid square of Great Britain. It provides users with access to the information from the **Countryside Survey 1990** carried out by the Institute of Terrestrial Ecology, which built on earlier surveys of 1978 and 1984 and which contains information on habitats, landscape features and vegetation. It has incorporated the earlier CORINE results, noted above, at a 1 km resolution and shows the current state and recent changes to the countryside. Additional datasets include summary data for 1990 on vegetation, soil and geology.

Information can be obtained from the distributing agents:

Institute of Hydrology
Maclean Building
Wallingford
Oxfordshire OX10 8BB
Tel: 01491 838800
E-mail: softdev@ioh.ac.uk

CIS operates using MS-DOS software on a standard PC with at least a 486 microprocessor, 5 Mb RAM and 30 Mb of free hard disc space.

Any other data that can be represented at a 1 km resolution can be incorporated into this system and overlaid with other factors and minor modelling carried out. In this way CIS will be of use to national or strategic and regional planners monitoring and controlling change in the land use and the environment.

TYPE OF INFORMATION AND MAIN SOURCE	STRATEGIC LEVEL	LOCAL LEVEL	SITE SPECIFIC LEVEL
Land Utilisation Survey maps Kings College, London		1:25 000	1:10 000 field maps
CORINE land cover maps European Environmental Agency Task Force	1:100 000 maps GIS data		
CIS data Institute of Hydrology	1 km resolution information		

Table 13 Types of land-use data and their main uses

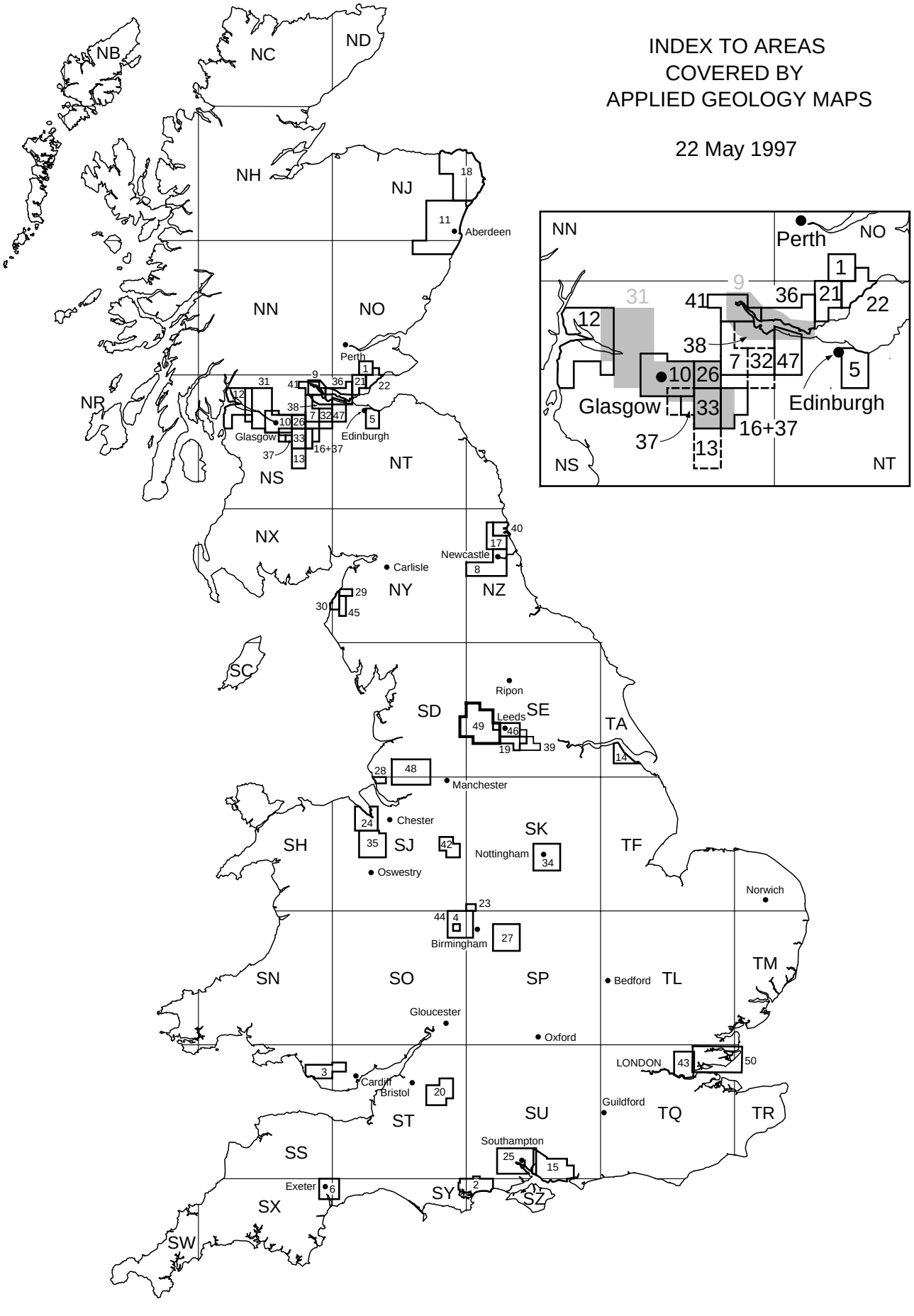


Figure 1 Index map of availability of Applied Geology Mapping projects

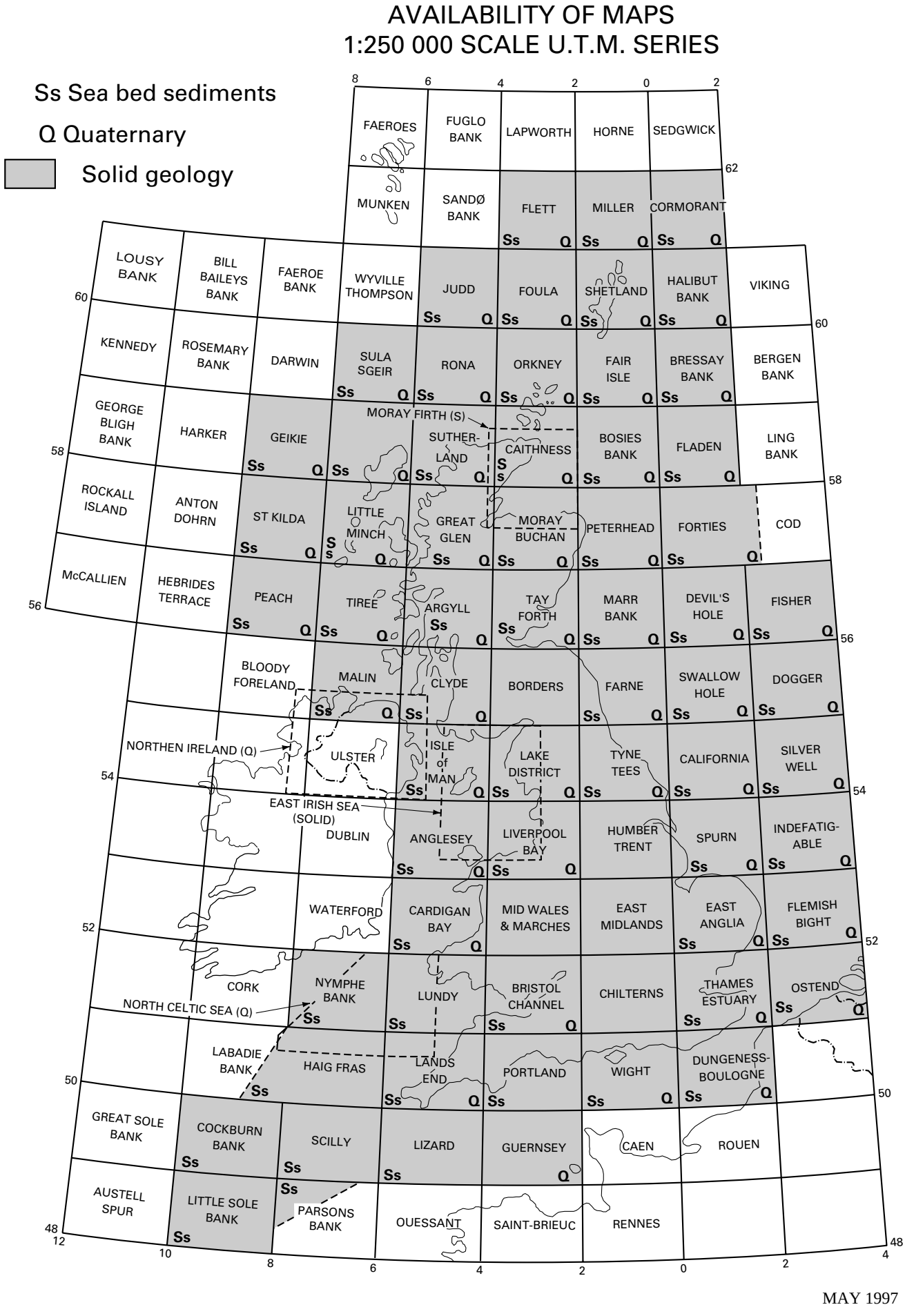


Figure 2 Index map of availability of 1:250 000 scale geological maps

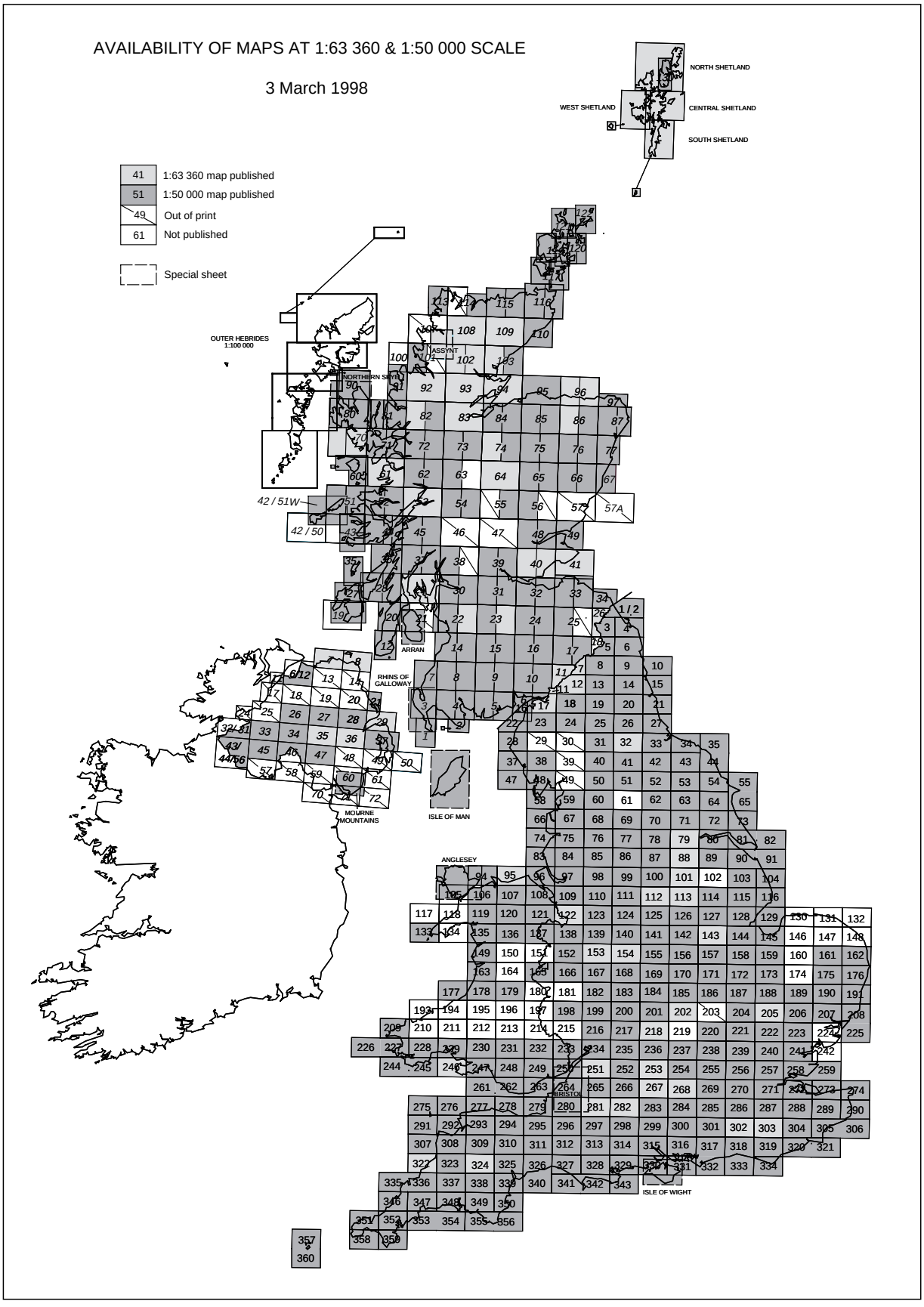


Figure 3 Index map of availability of 1:50 000 and 1:63 360 scale geological maps

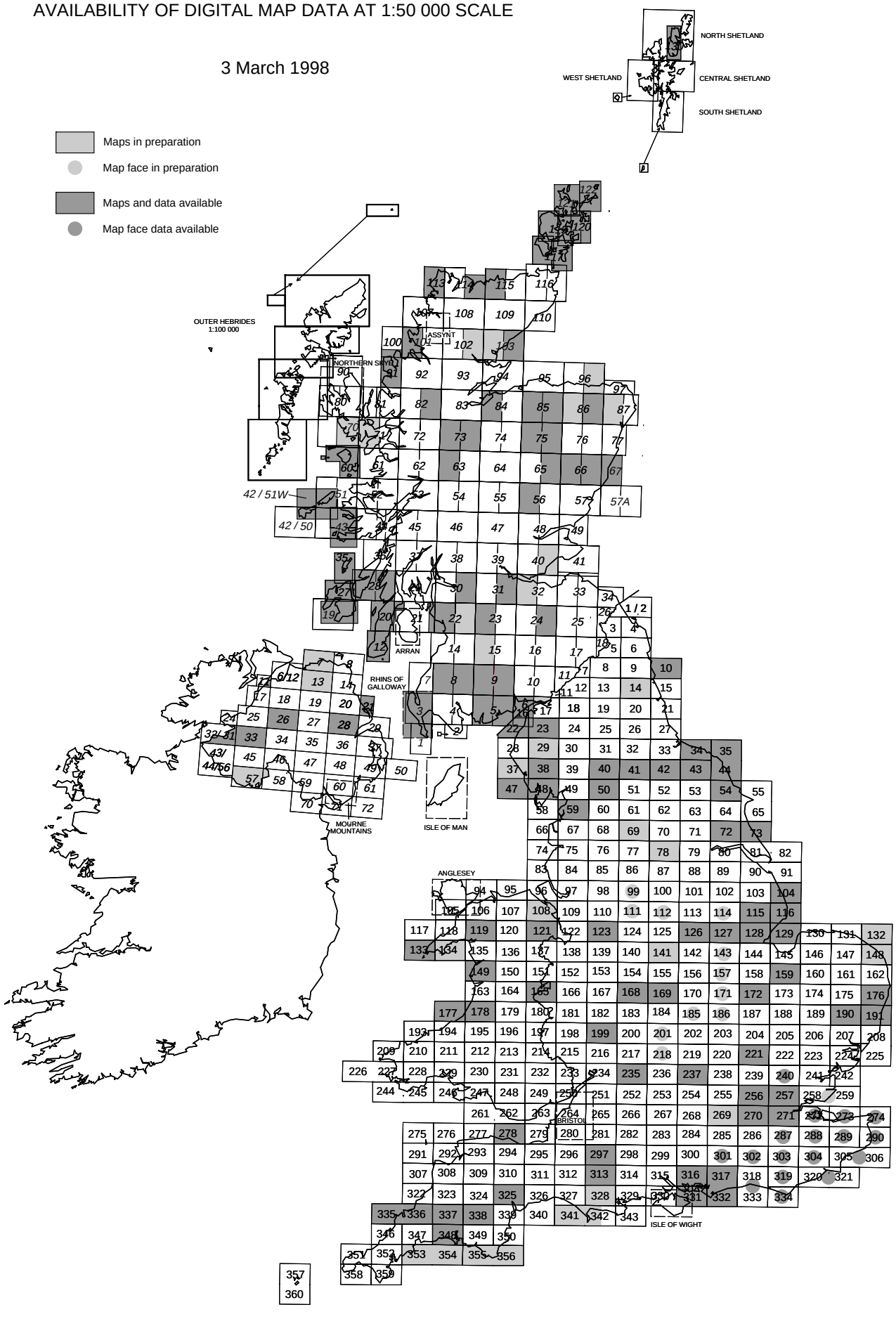


Figure 4 Index map of availability of digital geological map data at 1:50 000 scale

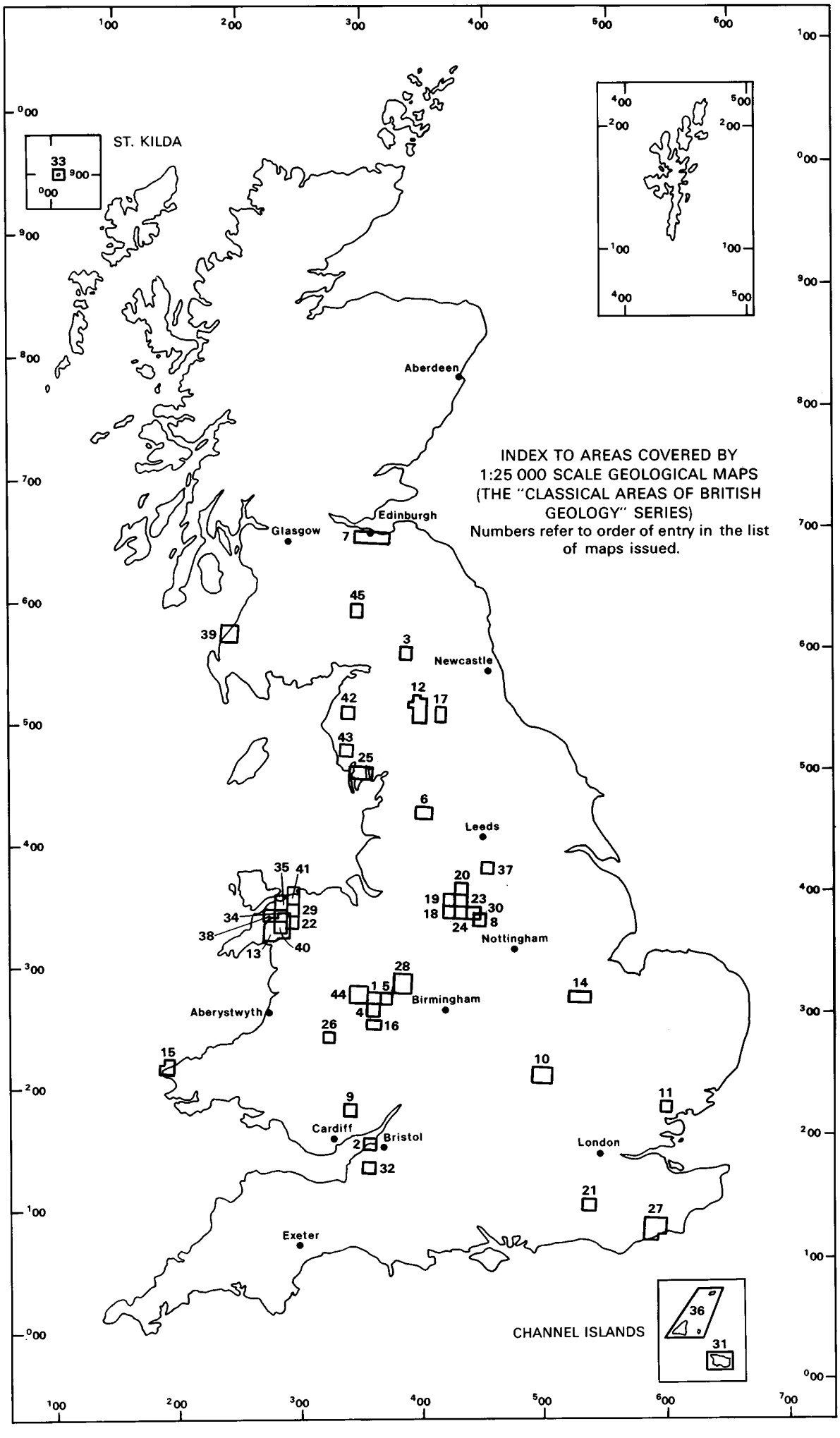


Figure 5 Index map of availability of 1:25 000 scale geological maps

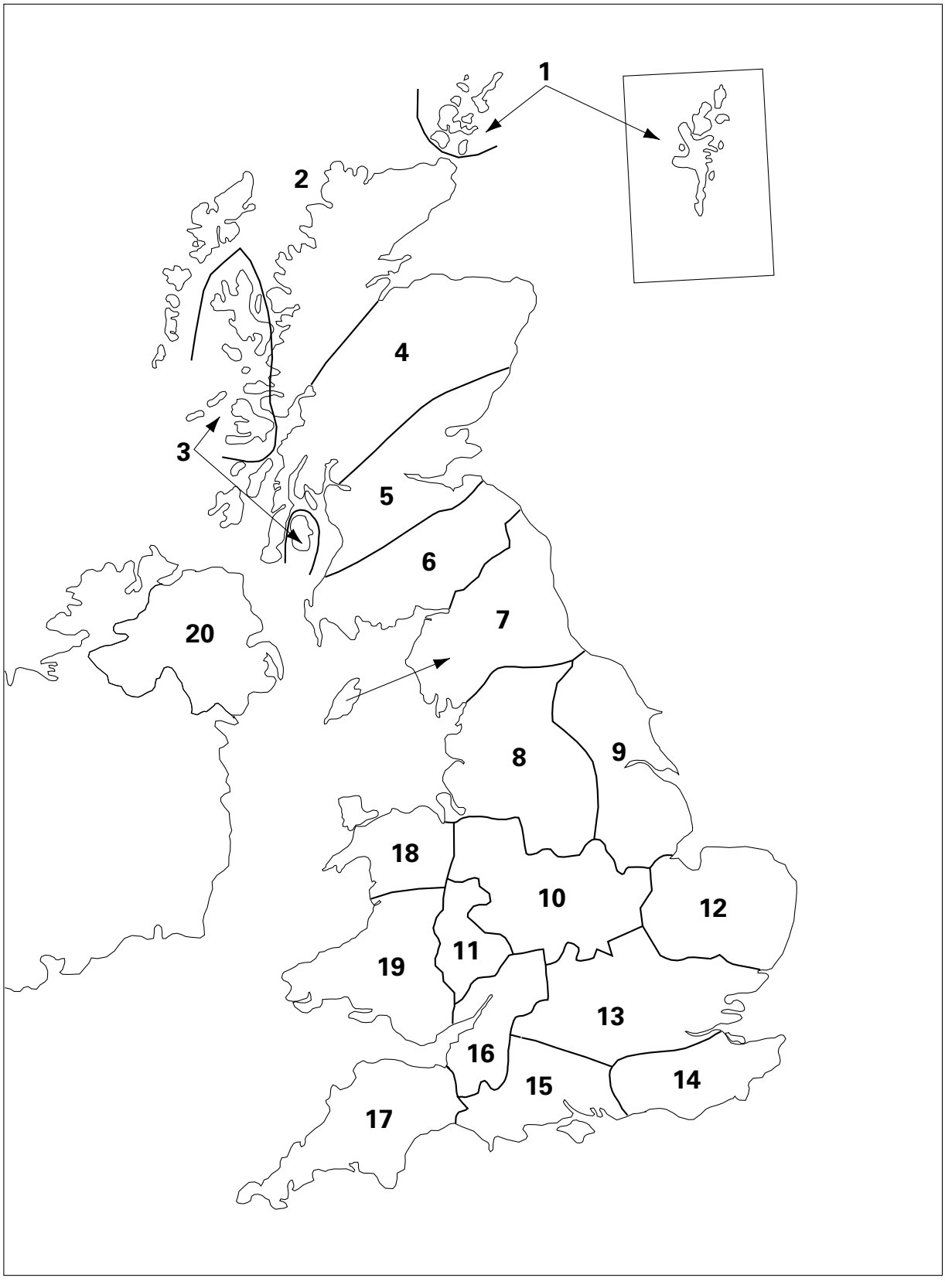


Figure 6 Index map of areas covered by British Regional Geology Guides

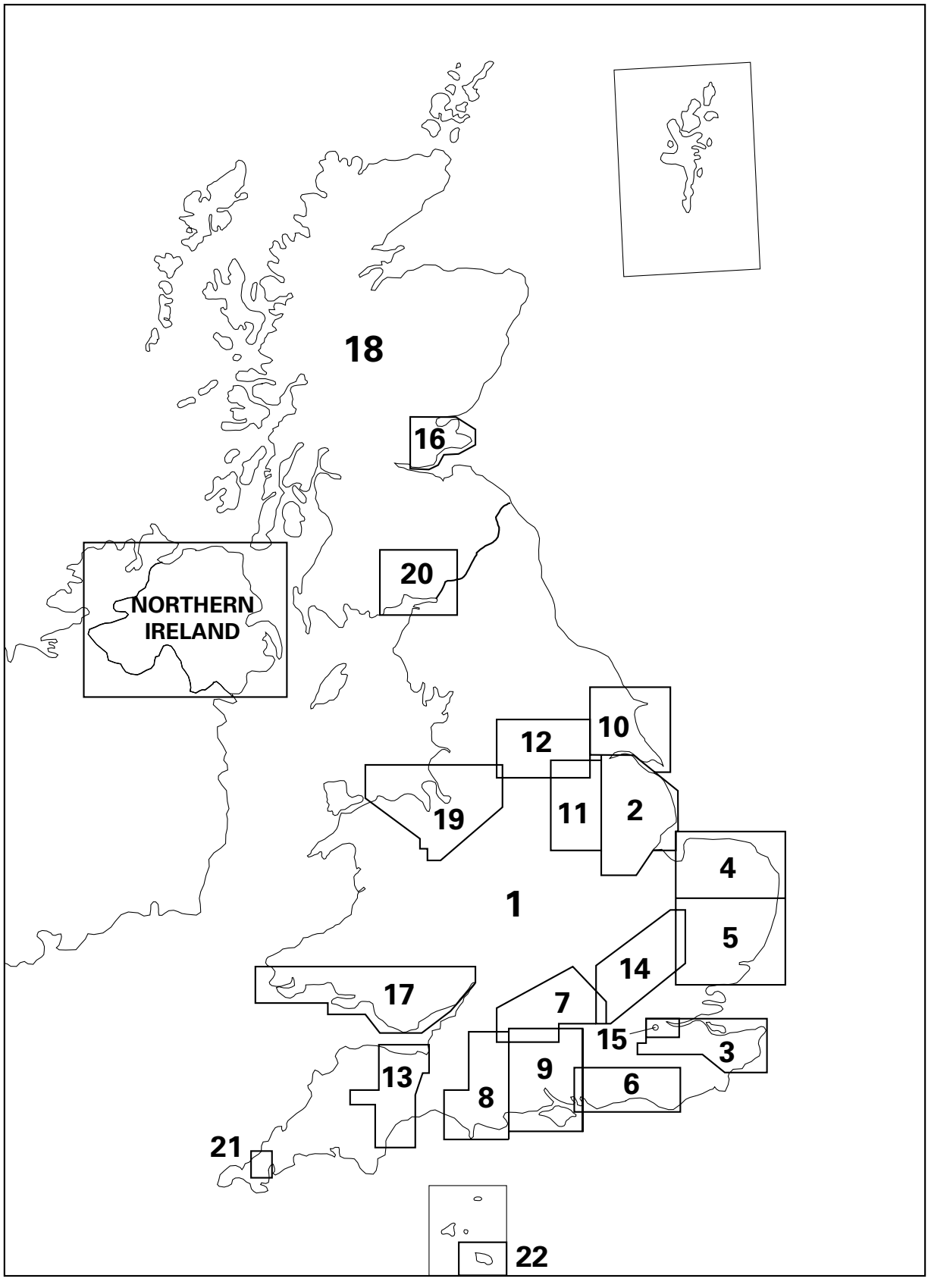


Figure 7 Index map of areas covered by hydrogeology maps

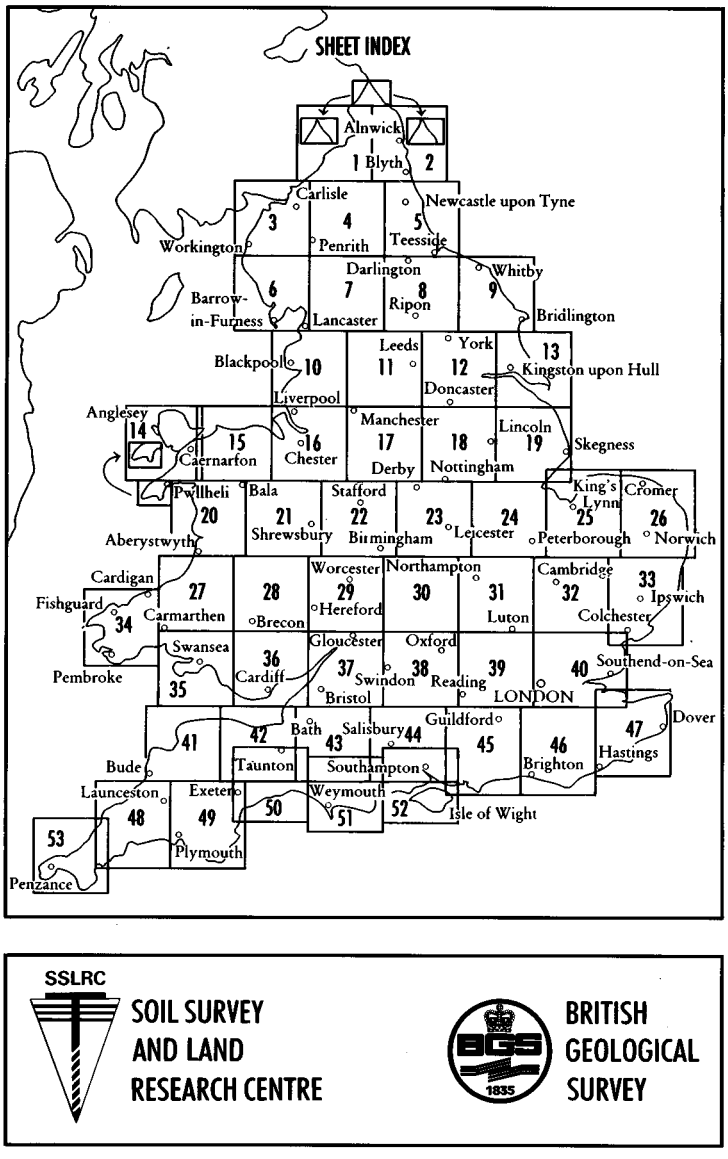


Figure 8 Index map of areas covered by Groundwater Vulnerability maps

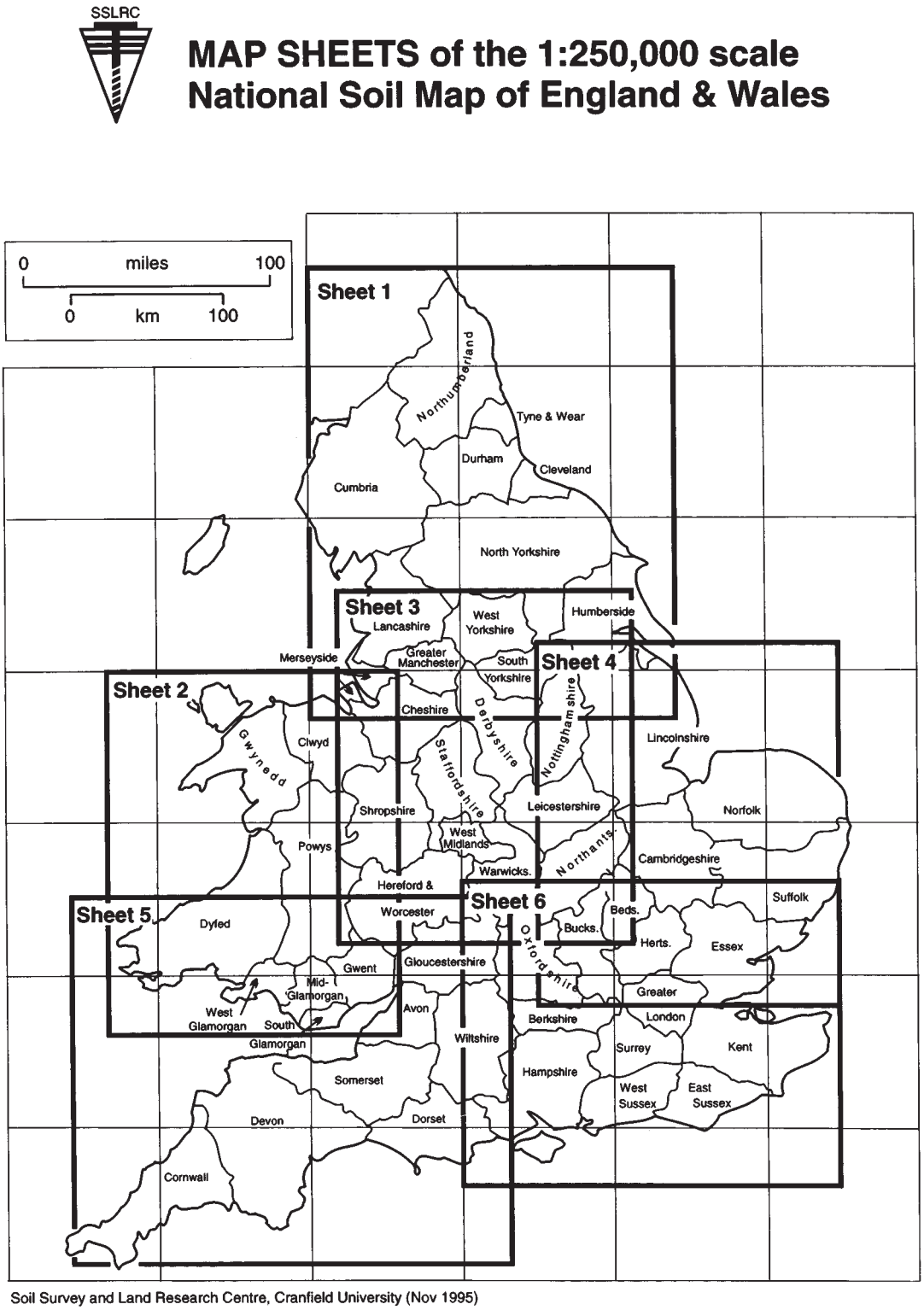


Figure 9 Index map of availability of 1:250 000 scale soil maps

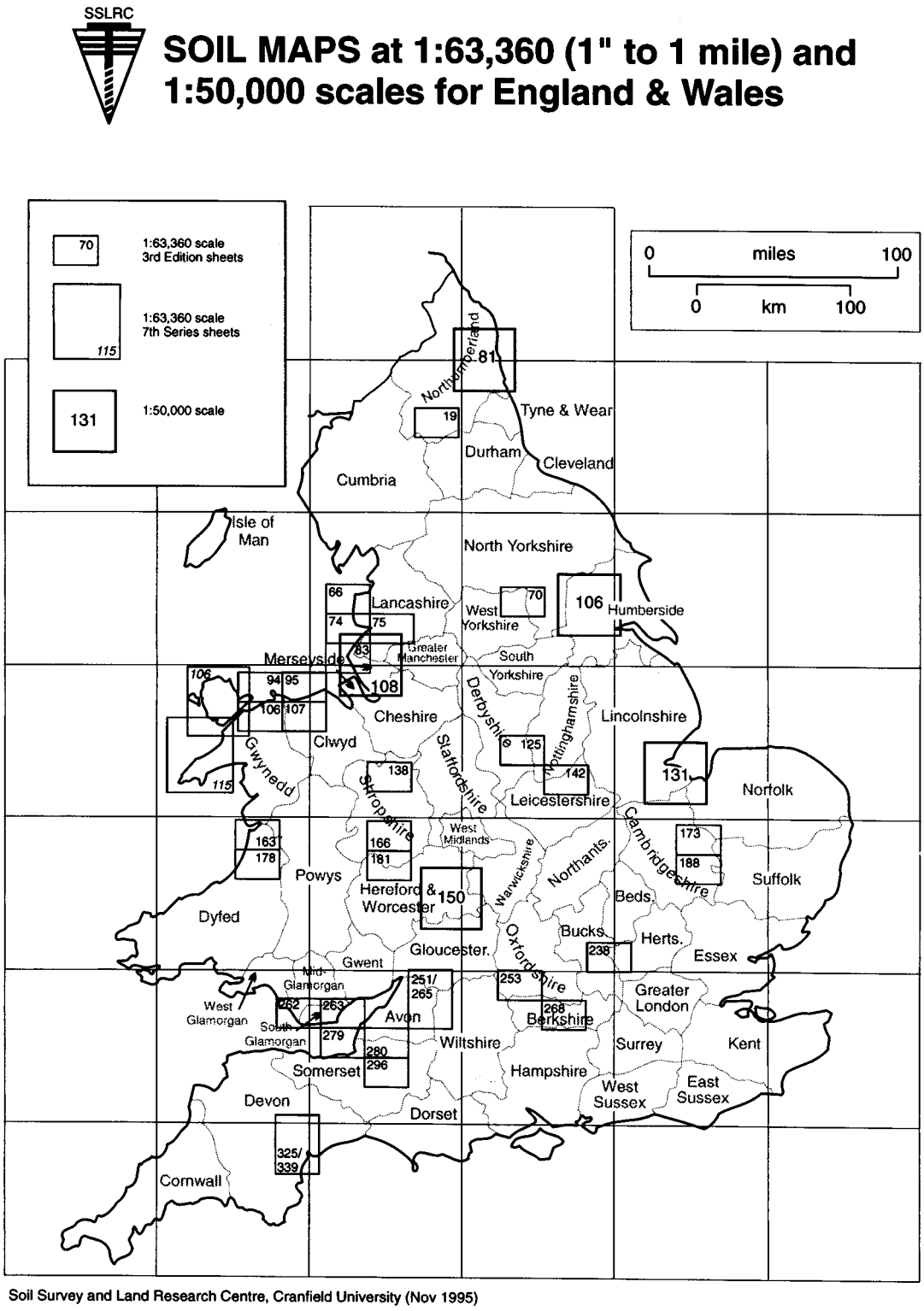


Figure 10 Index map af availability of 1:63 360 and 1:50 000 scale soil maps

SSLRC

SOIL MAPS at 1:25,000 (2½" to 1 mile) scale for England and Wales

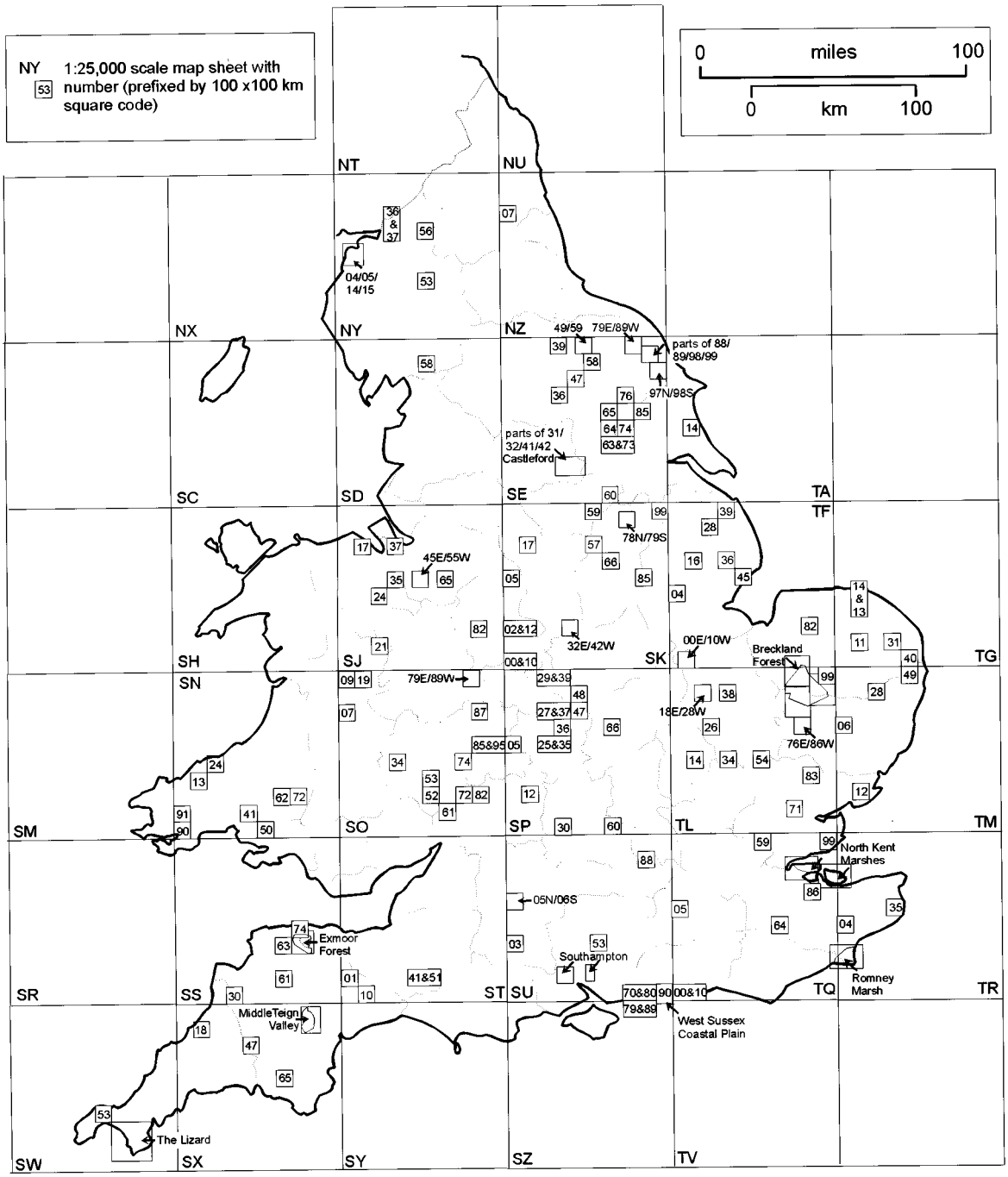
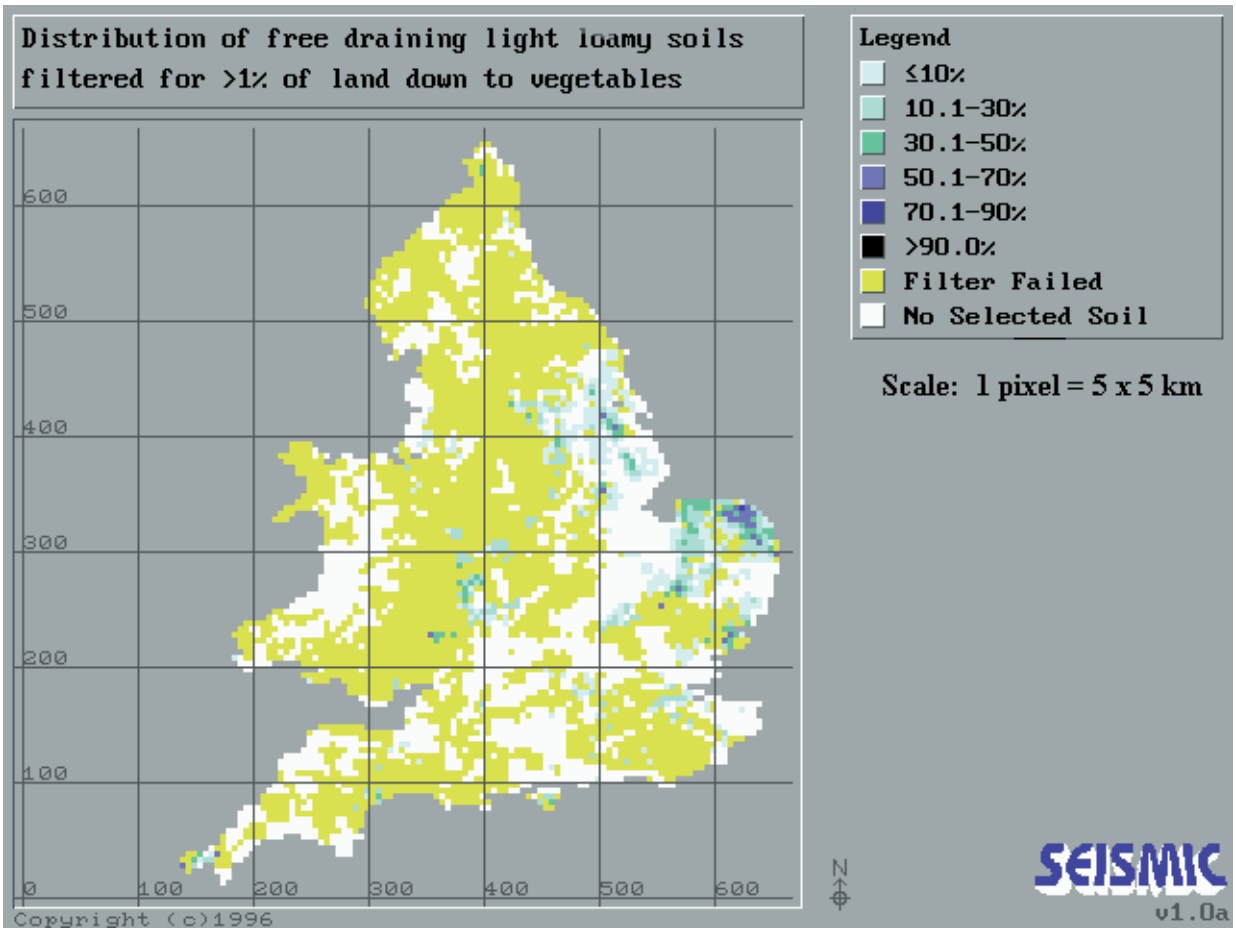


Figure 11 Index map of availability of 1:25 000 scale soil maps



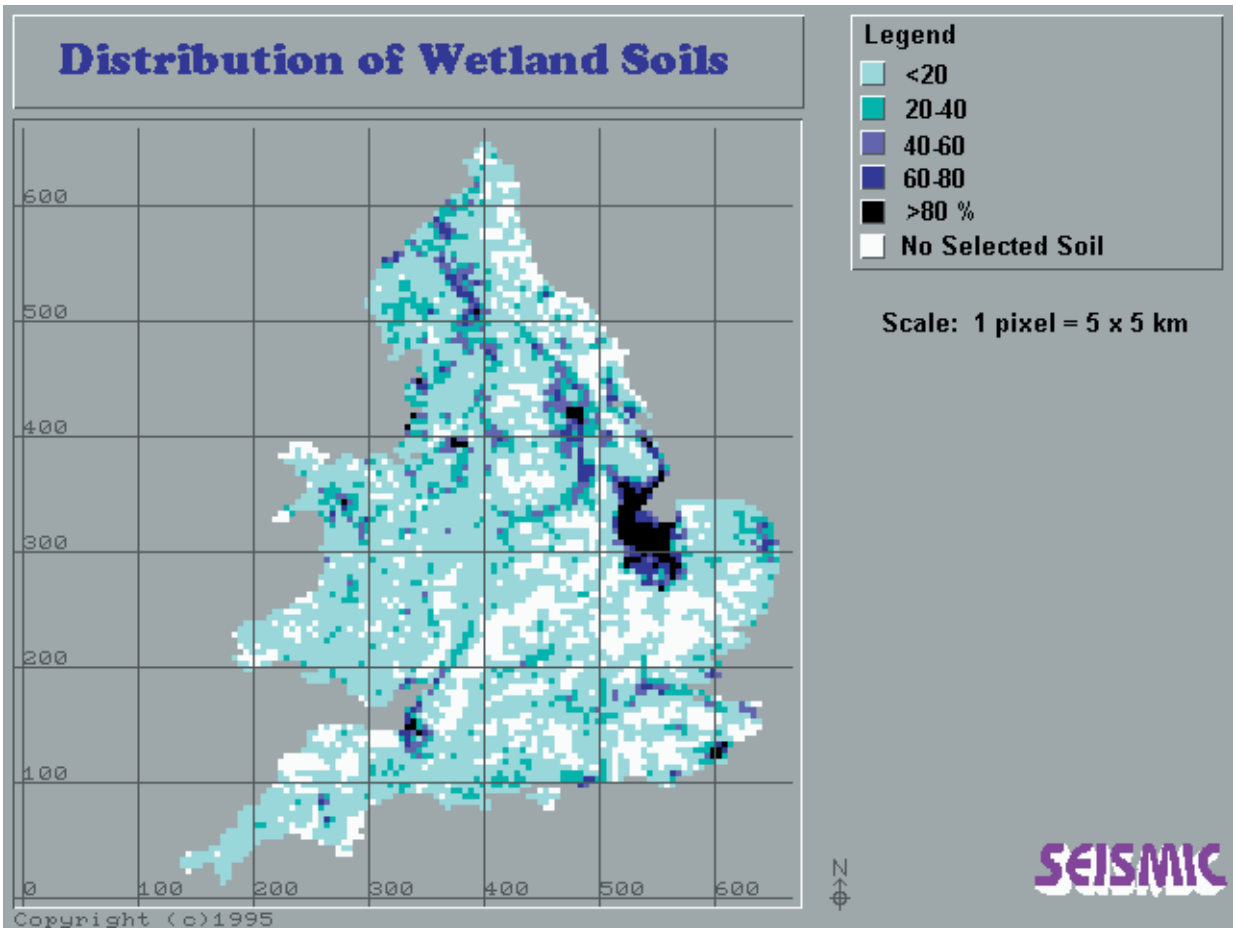


Figure 12 Examples of maps generated by SEISMIC software.

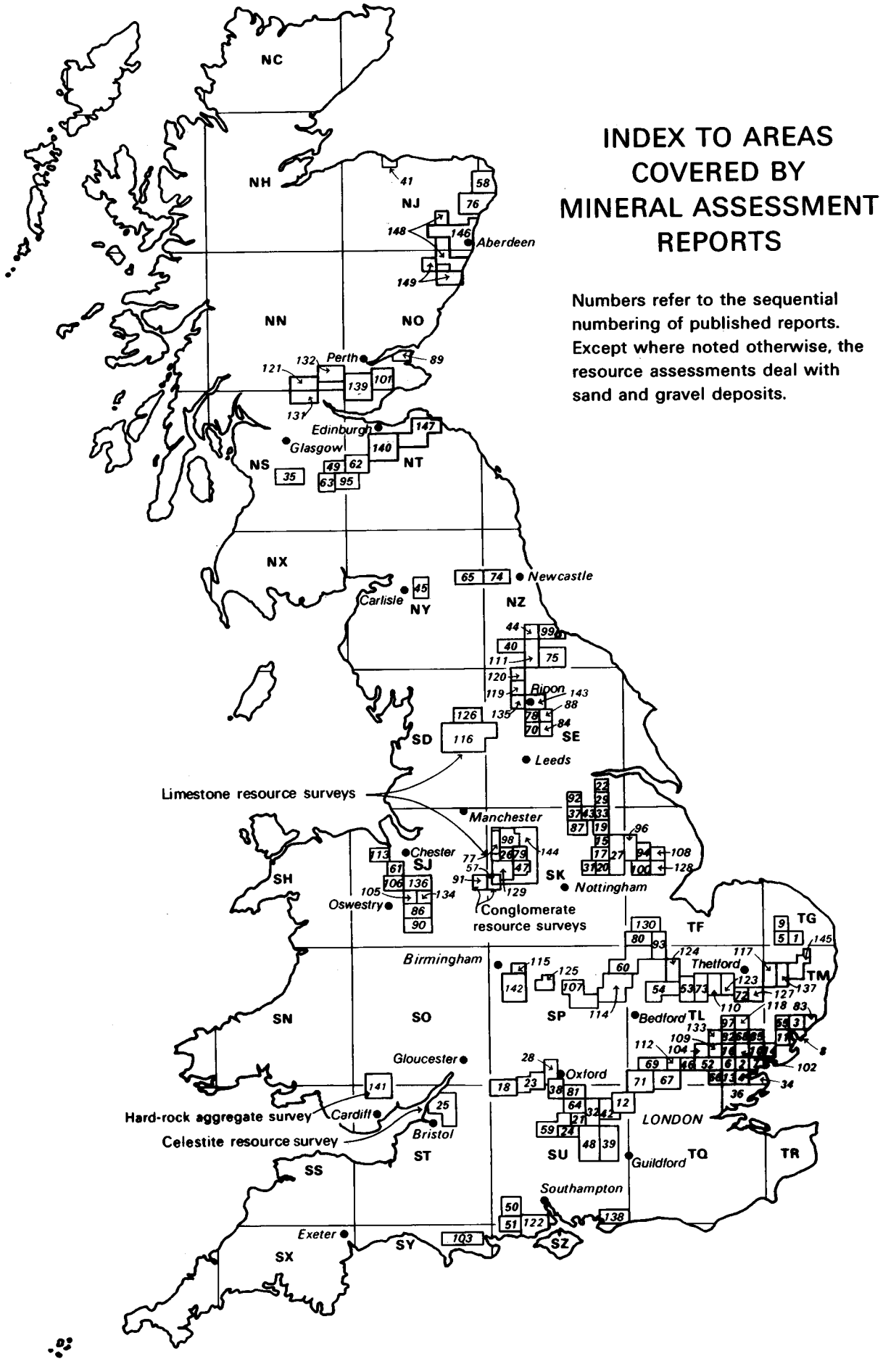


Figure 13 Index map of areas covered by Mineral Assessment Reports.

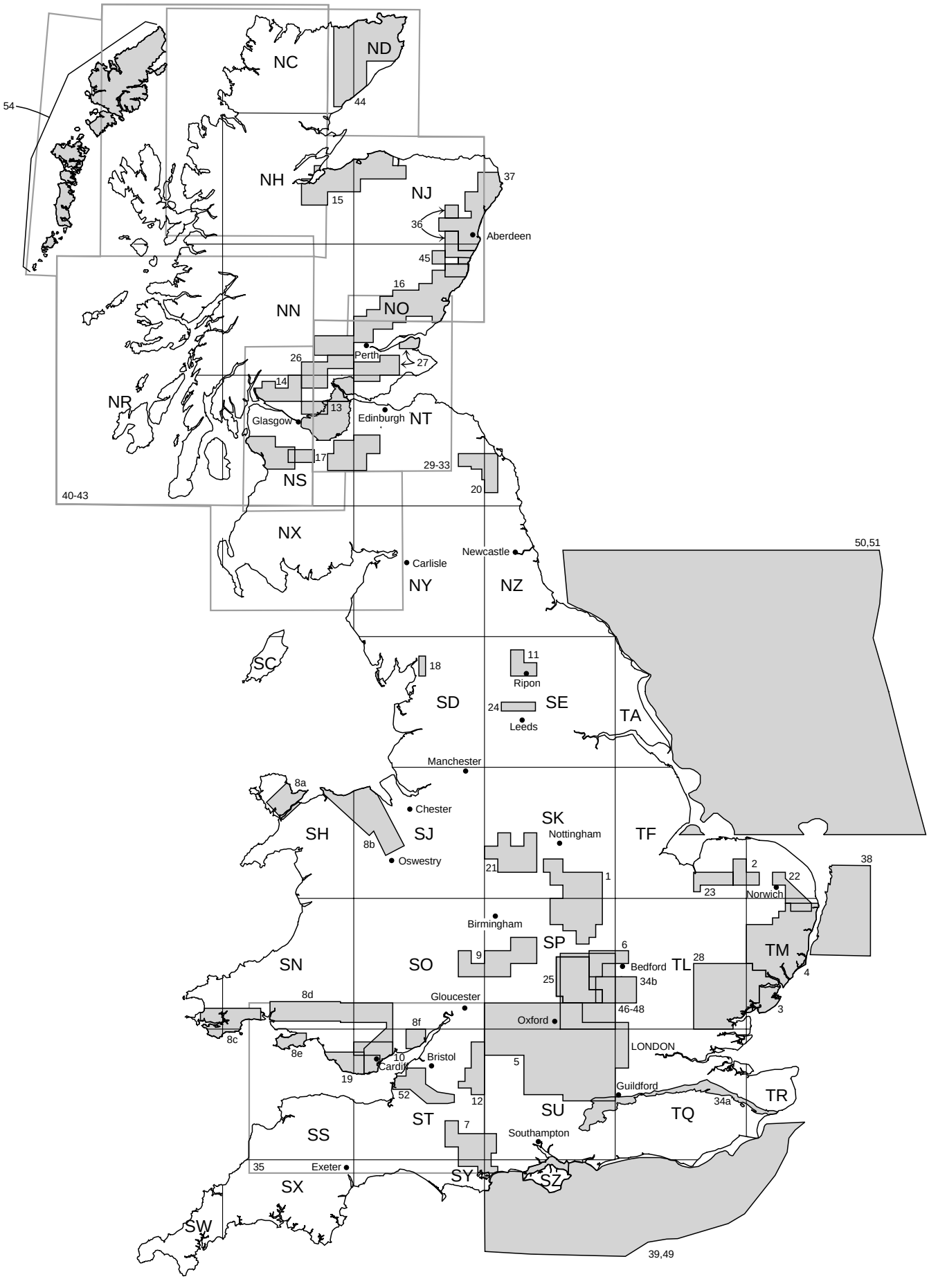


Figure 14 Index map of areas covered by Bulk Mineral Assessment maps

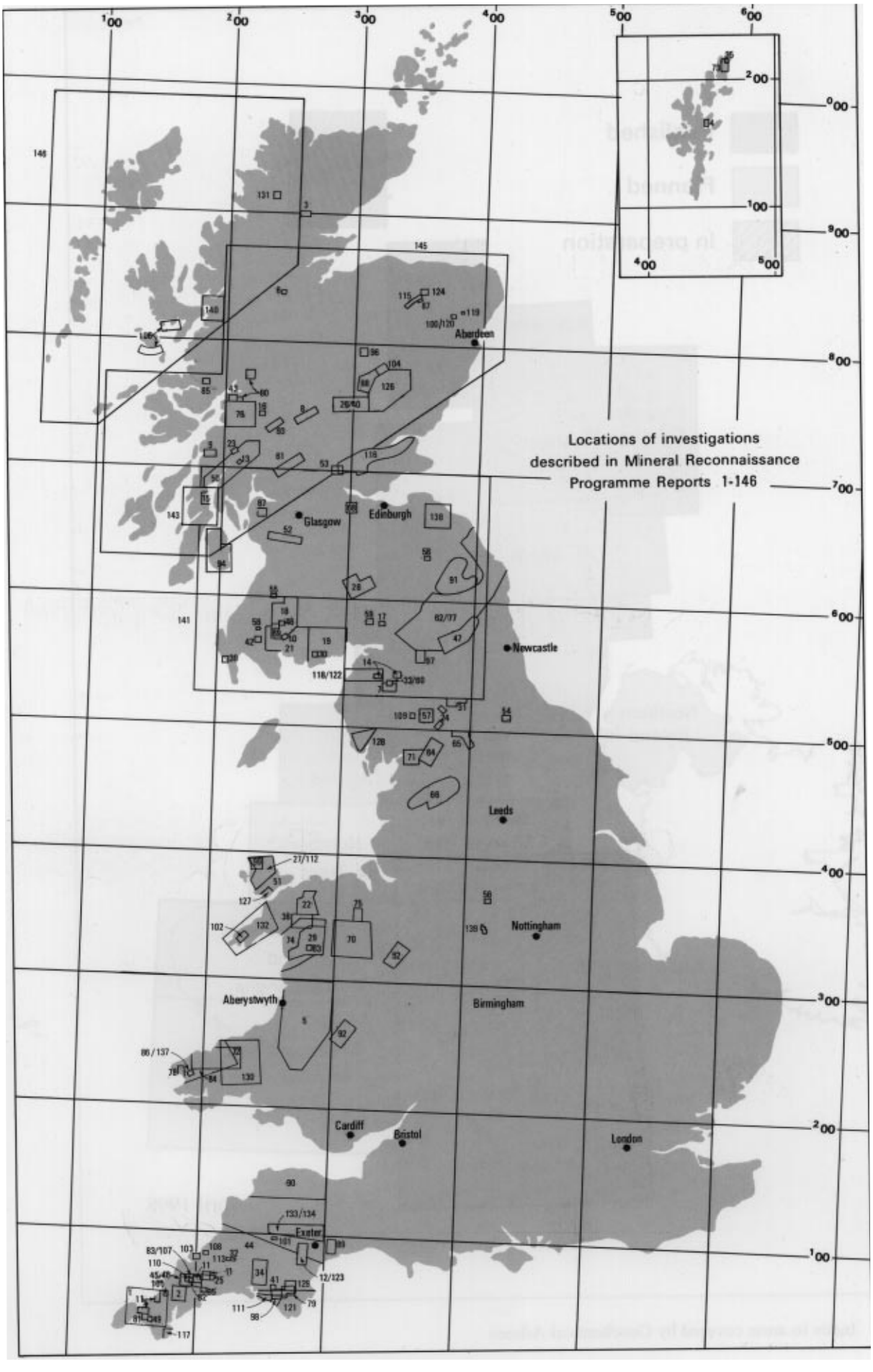


Figure 15 Index map of areas covered by Mineral Reconnaissance Reports.

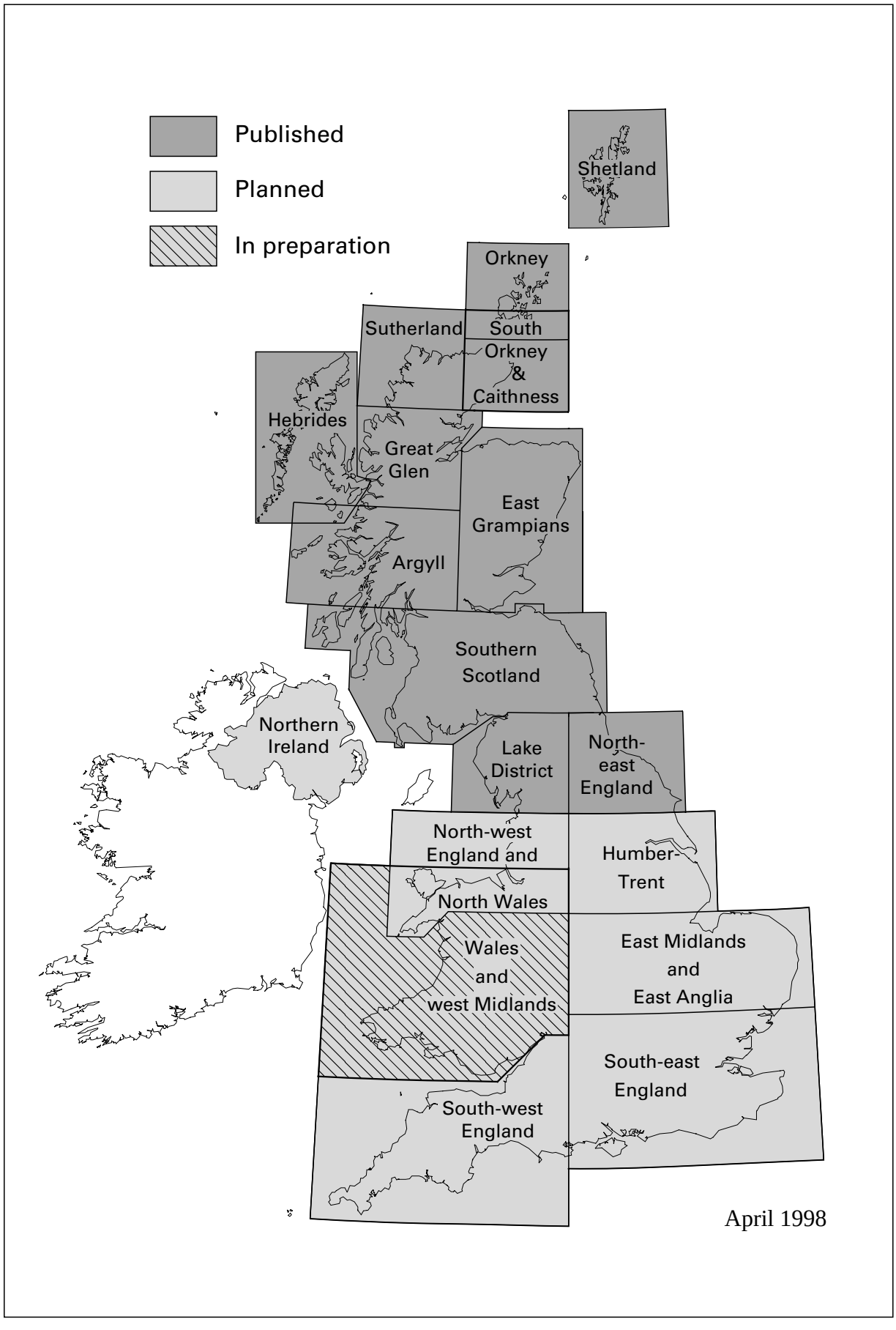


Figure 16 Index to areas covered by Geochemical Atlases