Some guidance on the use of digital environmental data

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Environment Agency

BGS Technical Report WE/99/14

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National Groundwater & Contaminated Land Centre
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PREFACE

This Report arises from a project jointly funded by the National Groundwater and Contaminated Land Centre of the Environment Agency and the British Geological Survey (BGS). The aim is to provide some practical guidance on using geographical information systems (GIS) and digital environmental data for anyone managing land quality issues. GIS is a powerful tool for managing and visualising spatially related digital data and is being used increasingly by local authorities (LAs), the Environment Agency (the Agency), industry and consultancies. There is a need to provide some technical advice in order to encourage the application of GIS in land quality investigations including planning. The Report is planned to be broadly usable for a variety of land quality issues including unstable ground, land contamination, conservation and sustainable development.

Sustainable development and Agenda 21 issues now form an important environmental framework for many businesses and local authorities. An underlying aim was to produce a Report that would contribute to good practice in public and private bodies when they need to report on the state of the environment or on a particular site. A key aim of the Agency in carrying out its advisory function in land contamination is to promote efficient information exchange.

This Report is designed to contain information on digital environmental data holdings, to describe how these datasets can be used in GIS and how GIS can contribute to more effective land quality investigations. The Report aims to give the novice GIS-user the confidence to get started with digital data management and analysis systems, and for the experienced GIS-users the re-assurance that what they are already doing is correct. The widespread use of GIS technology by LAs and other users will contribute to the improvement of decision- and policy-making processes in, for example, environmental health, land-use planning, building control, conservation and groundwater protection. Given time, costs are likely to be saved through more efficient environmental data management.

Part IIA of the Environmental Protection Act 1990 uses a risk-based approach to the identification of contaminated land. Within this approach, the presence of one or more significant pollutant linkages (i.e. source-pathway-receptor linkage) is required for the identification of contaminated land. Good practice guidance for identifying, assessing and management of land contamination is therefore required. An example of such is the DETR/Agency Handbook of Model Procedures for the Management of Contaminated Land (Contaminated Land Research Report CLR 11). This has been used by the authors as a framework for demonstrating applications of GIS and digital data. Some case studies were needed to supply instructions for users wishing to build a GIS for land contamination purposes. Three local authority case examples were selected: the London Borough of Newham; Leicester City Council; and the East Riding of Yorkshire Council. These were chosen for their different land use characteristics and because of the varying degrees of local authority use of GIS in land quality management.

One of the purposes of the project was also to set out the advantages and benefits to local authorities from establishing a GIS-based programme to help meet their needs on land-quality related work. The feedback that was obtained by consultation positively supports a digital/GIS approach.

EXECUTIVE SUMMARY

Geographical information systems (GIS) are being used increasingly in local authorities (LAs), the Environment Agency (the Agency), consultancies and industry. This project, jointly funded by the Agency and the British Geological Survey (BGS), has provided a Technical Guidance Report to encourage and guide the application of digital environmental data in GIS for users addressing land quality issues. The Report is broadly usable for a variety of land quality issues including unstable ground, conservation, contaminated land and sustainable development.

A number of local authorities were contacted and visited to establish the current status of digital data holdings, the data requirements for different geographical areas and to determine the range of IT facilities in place. This information was helpful in the production of this Report by providing a focus on some of the needs of the LAs and other end-users. The Report will enlighten the reader/user by describing the digital environmental information and data that are available, how these can be used in GIS and how GIS can contribute to improved land quality investigations. In particular, the report aims to give a new GIS-user the confidence to understand and get started with digital data management and analysis systems, and for experienced GIS-users the reassurance that what they are doing already is correct.

Digital and non-digital data needs are identified and described in the context of land quality issues regulated by the Agency and local authorities and addressed by industry and consultancies. Sources of data needed to meet the identified requirements are catalogued, with particular emphasis on available digital data. Suppliers/owners of data, formats, extent of data coverage, scales of mapping and costs along with availability are detailed in the Report. Advice on preferred digital data formats for best handling and transfer is also provided. Where digital datasets are unavailable, the non-digital formats are catalogued and practical notes made on their characteristics. The pathways for migration from raw data, paper records and printed maps to digital records are described and practical advice is provided. The problem of data being imported at one scale and being used improperly at a different scale is highlighted as a significant limitation to be aware of.

A risk-based approach to the management of land contamination is good practice and such an approach supports Part IIA of the Environmental Protection Act 1990, which deals with contaminated land. The concept of a pollutant linkage i.e. a source-pathway-receptor linkage, is useful for assessing risk and identifying potentially contaminated land. This source-pathway-receptor idea has been used as a framework for focussing needs and demonstrating applications of different GIS and digital data in three local authority areas. The GIS case studies presented are for the London Borough of Newham, Leicester City and the East Riding of Yorkshire. These local authority areas were chosen for study because they reflect different land use characteristics and different degrees of GIS development within each authority. The demonstration GISs for each area are described in the report, along with details of the steps taken to produce them to the various stages of development possible within the time-frame and funding resources of the project. The GIS developed for Newham is the most advanced of the three. It contains features for report writing and for prioritising contaminated land in terms of risk to schools and housing. These three case studies supply useful illustrative instructions to enable users to follow the steps involved in building a GIS for land quality purposes.

Qualitative feedback from the Newham Local Authority, which had already invested in GIS, demonstrated the advantages of spending resources to set up and maintain a GIS-based information management system and showed the benefits which can be achieved through its use. The eventual widespread application of GIS technology by LAs and other users will contribute to the improvement of the decision- and policy-making processes in, for example, environmental health, land-use planning and building control, with likely overall cost savings in the long-term.

KEY WORDS

Environmental data, digital data, Geographical Information System (GIS), land quality, land contamination, contaminated land, unstable ground, risk assessment, sustainable development, local authorities

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GLOSSARY

Address Point	Address Point is an Ordnance Survey data product that provides a national grid coordinate and a unique reference code for every postal address in England, Scotland and Wales.
ASCII	ASCII stands for American Standard for Computer Information Interchange. ASCII assigns numbers to characters. For example a space is the number 32, the letter 'A' is 64, 'B' is 65, and so on. It is the standard used by all computers to represent text.
Avenue	Avenue is the programming language included in ArcView (a proprietary GIS package). This allows an ArcView GIS to be customised to modify its functionality and to provide extra functionality such as a report generator.
Blue lines	Vector polygons of water courses (rivers, streams and lakes) derived from OS data and supplied by the Institute of Hydrology under licence.
CAD	Computer Aided Design
CD-ROM	Compact Disk-Read Only Memory. CD-ROM is an optical storage medium. A CD-ROM 5.25-inch disk can hold about 650 megabytes of information.
CLEA	Contaminated Land Exposure Assessment Model. A model developed specifically to derive soil guidance values relevant to human health risks.
CONSIM	CONSIM is an Agency program for modelling the risks of land contamination moving into water courses and aquifers.
DAT	Digital Audio Tape is a high-density storage medium used for transferring and backing up large datasets.
Database	A database is a logical collection of interrelated information, managed and stored as a unit. A GIS database includes attribute information about the spatial features held in the GIS, such as the name of a river.
Data layer	Data layers organise a GIS by subject matter e.g., soils, roads, and wells. Layers can be viewed in a GIS individually or in combination.
Dataset	A dataset is a digital file of information which can be imported into a GIS to create a data layer.
DEM	Digital Elevation Model

.dbf file	A .dbf file is a dBase database file. It is the format used by ArcView to store attribute information, such as the name of a river.
.DXF file	Data Exchange Format. A format for storing vector data in ASCII or binary files. Used by AutoCAD and other CAD software for data interchange.
FTP	File Transfer Protocol (FTP) provides a method for users to connect to a remote computer via a network and transfer files back to his or her own computer.
GIS	A Geographical Information System (GIS) is a software package capable of showing both graphical information (digital maps) and associated attribute information (from a database). Typical GIS functionality includes, data entry, spatial and textual querying, data analysis and the production of hardcopy maps.
Image catalogue	An image catalogue is an organised collection of spatially referenced geographic images that can be accessed as one logical image theme. An image catalogue typically contains images that depict the same thematic information for a given geographical area of interest.
IPC/IPPC	Integrated Pollution Control/Integrated Pollution Prevention and Control
JPEG	The JPEG file format for colour-rich images was developed by the Joint Photographic Expert Group (JPEG) committee. JPEG compresses graphics of photographic colour depth better than competing file formats, and it retains a high degree of colour fidelity. This makes JPEG files smaller and therefore quicker to download.
LANDSIM	LANDSIM is an Agency program for modelling the risks of landfill contamination moving into water courses and aquifers.
LZW compression	Lempel-Ziv Welch (LZW) compression. An algorithm used to reduce the size of files, e.g. for archival or transmission.
MapInfo MIF/MID files	MIF/MID files are the data format used by MapInfo to import and export layers of information. Most commonly used GIS packages (such as ArcView) can import data in MIF/MID format.
MegaByte (MB)	A megabyte is a unit of measure consisting of 1024KB. By convention, when referring to drive capacity however, 1MB means 1 million bytes.

Metadata	Metadata is a textual description of a data set. It highlights all the information a user of the dataset should be aware of, to use it correctly e.g. date produced, scale, projection, error information, etc.
NNR	A National Nature Reserve (NNR) is the land declared under the National Parks and Access to the Countryside Act (1949) or Wildlife and Countryside Act (1981), as amended.
Object Oriented	Object Oriented programming is a style of programming based around the concept of objects and operations that can be performed on these objects. An object represents a real world, and it may be a map or database table, etc., in the GIS.
PackBits compression	PackBits is a compression algorithm used to reduce the size of data files e.g. Tiff graphics files.
Polygon	Polygons are used in GIS to represent areas. A polygon is defined by the arcs that make up its boundary and an associated attribute that describes the geographic feature it represents.
Ramsar site	A 'Ramsar site' is the land listed as a Wetland of International Importance under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention) 1973.
Raster data	A cellular data structure composed of rows and columns for storing images. Groups of cells with the same value represent features, such as a road or river.
SAC	A Special Area of Conservation (SAC) is the land designated under Directive92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora.
Shape file	A Shape File is the internal format that ArcView uses to store a layer of information. Layers can be moved from one ArcView GIS to another via the shape files. A shape file consists of three physical data files (.shp, .dbf, .shx files – see below).
Shape file formats	The shape file format defines the geometry and attributes of geographically-referenced features in three files with specific file extensions. These are:
.shp	.shp - the file that stores the feature geometry e.g. the coordinates that make up a river;
.shx	.shx - the file that stores the index of the feature geometry;
.dbf	.dbf - the database file that stores the attribute information of features e.g. the names of rivers.
SPA	A Special Protection Area (SPA) is the land classified under Directive 79/409 on the Conservation of Wild Birds.

SSSI	A Site of Special Scientific Interest (SSSI) is the land notified as an SSSI under the Wildlife and Countryside Act (1981), as amended.
Tiff file	Tagged interchange (image) file format. An industry-standard raster data format. TIFF supports black-and-white, grey-scale, pseudo-colour, and true-colour images, all of which can be stored in a compressed or uncompressed format. TIFF is commonly used in desktop publishing and serves as an interface to numerous scanners and graphic arts packages.
Vector data	A coordinate-based data structure commonly used to represent linear geographic features. Each linear feature is represented as an ordered list of vertices.
www	World Wide Web i.e. the Internet.
ZIP discs	ZIP discs are high-density floppy discs capable of holding up to 250MB. A ZIP drive is needed to read and write to these discs.

1 INTRODUCTION

Geographical information systems (GIS) are being used increasingly by local authorities (LAs), the Environment Agency (the Agency), industry and consultancies. By providing some practical advice, this Technical Guidance Report aims to encourage the use of digital environmental data and GIS in the management of land quality issues. This Report will enlighten the reader/user in a practical way, showing what digital environmental information and data are available, what these can be used for and how GIS can contribute to improved land quality investigations.

The issue of land contamination has been one of the drivers for this piece of work. A risk-based approach to the management of land contamination is good practice, and such an approach supports Part IIA of the Environmental Protection Act 1990, which deals with contaminated land. The concept of a pollutant linkage i.e. a source-pathway-receptor linkage, is useful for assessing risk and identifying potentially contaminated land. This concept has been used as a framework for focussing needs and demonstrating applications of GIS and digital data for three local authority areas. The GIS case studies presented below in Section 6 are for the East Riding of Yorkshire, Leicester City and the London Borough of Newham. The widespread use of GIS technology by LAs and other land quality managers will enhance efficient information exchange and contribute to best practice in dealing with spatially related datasets concerning the environment.

2 ISSUES AND NEEDS

2.1 Key drivers

The key drivers behind land quality (LQ) issues are several. They include economic and technical developments, insurance and liability matters, EC Directives on landfill and groundwater, a raft of planning guidance for development, the Part IIA contaminated land regime, Integrated Pollution Control (IPC) measures and the Integrated Pollution Prevention and Control (IPPC) regime. Furthermore, it is Government policy to redevelop 'brownfield sites' for 60% of new residential homes. Also, sustainable development and Agenda 21 issues now form important overarching environmental controls on many business and local authority activities.

The LQ issues requiring geoscientific and land-use data and spatial information are:

- basic ground conditions (requires data on boundaries and rock properties)
- land contamination
- groundwater and surface water protection
- flooding
- subsidence
- conservation of landscape and habitats.

2.2 Issues arising from planning, development and conservation

This section is largely derived from Ellison and others (1998). The issues of importance for the planning, development and conservation of land include:

- provision of land suitable for development
- protection and development of mineral resources
- protection and development of water resources
- protection of agricultural land
- provision of waste disposal sites
- control of pollution
- conservation of landscape.

These issues all require the depiction of spatial information on plans with the designation of areas that are controlled, impacted and affected by material planning considerations. GIS is an ideal way of illustrating spatial relationships, and has the merit of allowing easy updating of the information in order to produce new plans (see Section 3).

The town and country planning system is a complex set of statutory regulations designed to control the development and use of land for the general good. Many of the elements are embodied in the Town and Country Planning Act 1990, as amended by the Planning and Compensation Act 1991. Many of the regulations require environmental surveys of the local authority areas, functions which potentially lend themselves to digital databasing and the use of GIS for best practice, e.g.

- under Section 30 of the Town and Country Planning Act 1990, LAs are required to keep under review, through surveys, the matters that may be expected to affect development and conservation;
- under the Town and Country Planning (Environmental Impact Assessment) (England & Wales) Regulations 1999, Schedule 4 of the Statutory Instrument 1999 No. 293 states that the information for inclusion in environmental statements will include the physical characteristics of the site and a description of the environmental aspects likely to be significantly affected by the development (population, fauna, flora, air, soil, water and landscape). A description of direct and indirect effects, both positive and negative, are required for short, medium and long time-scales.

Spatial information on material planning considerations may be best managed in GIS. Material considerations are laid out in a series of DETR Planning Policy Guidance (PPG) Notes and Circulars, Regional Planning Guidance (RPG) Notes and Mineral Planning Guidance (MPG) Notes. Compliance with some PPG Notes could be supported through applications of GIS e.g.

- PPG9: Nature Conservation (1994) requires fully adequate information on local species, habitats, geology and landform.
- PPG10: Planning and Waste (September 1999) requires the setting up of Regional Technical Advisory Bodies to provide expert advice on strategies and options for regional waste management. Regional waste plans will identify recycling, treatment and disposal targets to meet regional demands. The planning of regional facilities will take into account environmental, geological, hydrogeological and access constraints.
- PPG14: Development on Unstable Land (1990) and Annex 1 Development on Unstable Land: Landslides and Planning (1996) require that the stability of the ground be taken fully into account when deciding a planning application (see also Table 3.1 below in Section 3.3).
- PPG20: Coastal Planning (1992) requires that earth science and ecological information should provide a firm base for development plans to protect coastal environments.

Development plans are mandatory documents prepared by local authorities. They constitute a planning policy framework for an area over a 5 to 15 year period. They identify sites for new development and redevelopment and provide a context for planning applications. At the county level strategic policies are set out in structure plans, while districts have local plans. Metropolitan areas produce unitary development plans (UDP).

Development plans in general should highlight matters relating to ground hazards and constraints, resources and conservation. The Town and Country Planning (Development Plan) Regulations 1991 require planning authorities to have regard to environmental considerations in preparing a development plan. This involves an assessment of the environmental costs and benefits of the measures proposed in a plan. In doing so, some authorities produce state of the environment reports as part of the background research in preparing a development plan.

A state of the environment report will also help to serve a local authority's commitment to Local Agenda 21, which is the process of developing local policies for sustainable development. All LAs are under pressure to produce a Local Agenda 21 strategy by the end of the year 2000.

Both development plans and state of the environment reports can be produced with the aid of digital environmental datasets and preparatory survey work using GIS. Such methods should be of use too when a planning authority is required to undertake statutory consultations with a range of outside bodies and interested parties.

2.3 Issues arising from contaminated land

When enacted through Section 57 of the Environment Act 1995, Part IIA of the Environmental Protection Act (EPA) 1990 will introduce a duty on LAs and the Agency to operate a new contaminated land regime. Contaminated land is strictly defined at section 78A(2) of the EPA 1990 as:

'any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that –
(a) significant harm is being caused or there is a significant possibility of such harm being caused; or
(b) pollution of controlled waters is being, or is likely to be caused. '

This definition reflects the intended aim of the new regime, which is to enable the identification and remediation of land on which contamination is causing unacceptable risks to public health or the environment. The 'suitable for use' approach for dealing with existing land contamination and the associated risks to health and the environment takes into account the current and intended use of a site and enables resources to be concentrated on remediation and returning damaged land to beneficial use.

The UK legal and policy framework for dealing with land contamination relies on a robust risk-based approach, which recognises three main components:

1. the source or hazardous substance or contaminant agent;
2. the pathway or means by which the contaminant agent comes into contact with a receptor;
3. the receptor or entity that is vulnerable to adverse effects from the hazardous substance.

The identification of a *pollutant linkage* i.e. a source – pathway – receptor linkage, is the starting point when assessing whether a piece of land is contaminated land. There may be more than one pollutant linkage on a piece of land. A pollutant linkage may be time-dependent e.g. as the pathway characteristics of the site change over time. If all three elements of a pollutant linkage can be demonstrated to be operating, then an assessment can be made on whether significant harm or a significant possibility of significant harm is being caused to the receptor. If this assessment proves positive, the presence of a *significant pollutant linkage* is proven and the piece of land can be identified as contaminated land.

The statutory duties that will be placed on LAs under Part IIA are:

- inspect their areas to identify contaminated land
- determine contaminated land
- establish whether sites should be designated as 'special sites' and thus become the responsibility of the Agency
- serve remediation notices where necessary
- undertake assessment of best practical remediation option and tests for reasonableness
- consult other parties including the Agency
- compile and maintain registers
- consult the Agency on pollution of controlled waters.

The inspection by local authorities of their areas to identify contaminated land is essential if their other responsibilities under Part IIA are to be carried out. The responsibility of identifying contaminated land should not be treated in isolation. The information collated and the decision making processes involved are also required to support other key duties within the Part IIA regime. It is therefore important that an information management and decision support system is selected to facilitate as many aspects of the requirements of Part IIA as practicable. To enable this, careful consideration of data requirements and procedures for risk analysis are required.

Each LA will need to adopt and implement a strategy for identifying and prioritising contaminated land in a rational and efficient way. The methodologies adopted should draw upon all available information without unnecessary duplication of effort internally or with other agencies. Therefore the strategy should be to accommodate information received from the Agency and land owners and be able to store, process and analyse it in a suitable format. The use of GIS methods in this regard will be of great benefit (see Section 3), and will enable a more efficient means of delivering information to outside bodies like the Agency.

The responsibilities of the Agency under the Part IIA regime include:

- to provide information to LAs on land contamination
- to ensure remediation of special sites
- to maintain a register of special sites remediation
- to prepare a national report on the state of contaminated land
- to provide advice to LAs on the remediation of contaminated land

- to provide advice to LAs on identifying pollution of controlled waters.

Good practice guidance for identifying, assessing and management of land contamination is required, and an example of such, the DETR/Agency Handbook of Model Procedures for the Management of Contaminated Land (Contaminated Land Research Report CLR 11) can be used as a framework for applications of GIS and digital data.

In environmental management, three main principles are deployed:
1. risk assessment, where the risks are identified, estimated and evaluated;
2. risk management, where decisions are made to remediate and control the risk and the remedial controls and actions are implemented and monitored;
3. risk communication where the risks are explained and justified to the stake-holders and interested parties.

GIS is a highly suitable way (see Section 3) of managing the land-use and ground information in order to identify pollutant linkages, assess risks, make decisions and communicate outcomes.

2.4 Land contamination legacy

The land contamination legacy of the Industrial Revolution has affected many of the large urban areas in Britain including the West Midlands, South Wales, Merseyside, the North East and London. Soils in old urban and industrial areas in particular often contain a wide range of contaminants with elevated concentrations.

In addition there are special geographical factors arising from:

- metal mining e.g. in the South West, the Pennines and the Lake District;
- coal mining activities e.g. in South Wales, the Midlands and Yorkshire, the North East and East Kent. Colliery wastes occupy large areas of made ground in many built up areas of cities, and these wastes can hold heavy metal contaminants. Also the mined cavities and shafts may offer pathways for the migration of contaminants through the ground.
- oil wells in the East Midlands.

Many of these activities have affected the surrounding rural areas as well. All this spatial and geographically attributed information is best represented in formats compatible with GIS.

More details on the geographical distributions of contamination, both natural and man-made, can be found in the Environment Agency's R&D Project P5-019 'Information on Land Quality in the UK'. The Project Technical Reports cover sources of information on (i) land contamination and (ii) background contaminant concentrations in the UK. Much of this information and data is in digital or GIS formats.

2.5 Land contamination sources

It is possible to infer potential sources of contamination in the ground by examining present and former land use in a local authority area. The potential contaminants associated with the main industrial land uses are shown in **Table A.1 in Appendix 1**. This list should be used for

guidance only, as it is possible that not all contaminants will be present and others not listed may be. Only by detailed site investigation will the range of contaminants and their concentrations and chemical forms be determined. The information contained within Table A.1 is the result of a compilation of data sources including, DETR report CLR 3 (DoE 1994), Failey and Scrivens (1993), Cairney (1993) and the Department of the Environment Industry Profiles.

2.6 Data needs

The datasets required to meet land quality issues are listed below in a priority dictated by the requirements of populating a GIS to identify land contamination and unstable land. Different datasets are needed by different users, but many are common to all. The details of the datasets are given in Appendices 2 and 3.

Land use:

Ordnance Survey (OS) topographic maps
Unitary Development Plans, Structure Plans, Local Plans
Historical OS maps (County Series), which show former land use and thus may indicate potential contaminants
Street and trade directories
Pre-OS historical maps e.g. estate and tithe maps
Landfill data.

Geohazard information:

Subsidence
Shallow mining
Dissolution features
Shrink-swell clays
Slope instability (slope angles and aspects)
Compressible ground
Flooding potential.

Geochemical data:

Natural land contamination maps e.g. for radon potential, potentially harmful elements and for natural methane, carbon dioxide and oil seeps
Geochemical survey data
Consents for discharges of substances to waters
Authorisations under IPC for prescribed Part A and B Processes
Pollution incident records
Disposal of sludge records (site locations held since 1989 by the Agency).

Geological data:

Artificial deposits
Superficial deposits
Solid geology

Borehole data
Applied geology maps.

Hydrogeological and hydrological data:

Groundwater vulnerability maps
Water wells
Licenced abstraction
Groundwater Source Protection Maps
Surface water quality
Groundwater quality

Site investigation data:

LA reports (those site investigation reports with geochemistry analyses would be held in environmental health departments)
Utility site investigation reports
Contaminated Land Supplementary Credit Approval (SCA) programme reports and case studies.

Conservation data:

Sites of Special Scientific Interest (SSSIs)
Areas of Outstanding National Beauty (AONBs)
National Parks
Special Areas of Conservation (SACs)
Special Protection Areas (SPAs)
Marine nature reserves
Scheduled Ancient Monuments
Designated bathing beaches
Habitat data
Local conservation and nature reserves (from the county-based Wildlife Trusts).

3 GIS AND DIGITAL DATA CHARACTERISTICS

3.1 The nature of a GIS

A GIS is a digital system for the storage, manipulation, analysis and visualisation of spatial data. At the heart of a GIS is a database that allows the spatial data to be linked to attribute data. Spatial data is anything for which a grid reference can be given i.e. where something is. Attribute data is information about what is at a particular point. Maps are the most well known types of spatial data. They show the spatial distribution of features and the locational relationship of one object with another.

Many people are familiar with databases in their own right and not as part of a GIS. These databases are full of attribute information and may contain postcode information or grid references and therefore constitute spatial datasets. This spatial information can only be visualised if it is plotted onto a paper map. A GIS is a digital system that integrates both databases and maps to produce a powerful tool for analysing the environment.

What are the advantages in moving to digital mapping and analysis? It is a simple thing to read a paper map, but when two or more maps have to be combined and overlain, the operation becomes less straightforward. Using conventional techniques, an overlay trace would have to be prepared for each map. These traces would then have to be analysed using manual measurement techniques and a final map prepared. All of these maps would then be stored in a map chest. Any point information would have to be plotted by hand. If these points relate to a database, then the paper map would have to be cross-referenced with the database. Each time a different attribute was needed, a different set of plots would be required. Large areas would have to be covered by many maps, increasing the storage problem.

Using GIS, all these functions become more straightforward, as GIS was developed to make cartography and map analysis easier. Datasets containing both spatial and attribute data can be drawn together into a common structure, simplifying their analysis and manipulation. The increased performance of desktop computers means that questions can be asked of the data and answered rapidly, without the delays inherent in the time-consuming manual methods outlined above.

3.2 GIS characteristics

The choice of standards for recording temporal and spatial co-ordinates will allow for ready comparison of data from different sources. Since data may be accessed via GIS systems, adoption of British National Grid co-ordinates appears to be the most appropriate means of identifying locations. However, others, such as Address Point, postcodes etc, will also be important. If there are overriding reasons for the adoption of other co-ordinates, e.g. latitude/longitude, then tools to convert between co-ordinates may be required.

Similarly, GIS data should be held, manipulated and transferred in formats native to, or supported by, widely available GIS packages such as ArcView or MapInfo. Large amounts of data can be handled in such GIS and it is easy to view combined datasets. Usually the GIS is operable with other digital systems.

Again, the use of obscure or obsolete GIS that do not import or export these widely used formats should be avoided where possible, as considerable effort (and therefore costs) is often needed to re-format data when transfer to another system etc. is required.

3.3 GIS benefits

Most organisations with land management responsibilities possess GIS facilities nowadays, and some have service level agreements with the Ordnance Survey which could provide base mapping as a primary layer for inclusion in the GIS.

While the information needs of the LA environmental health, building control and planning departments are different, there is often a need to share data to ensure consistency of approach. Importantly, once a GIS has been developed and set up, it can be used by all members of staff, not just the GIS specialists. In principle, data management by means of a digital system will increase departmental cross-talk, make it easier to evaluate ground

conditions, and facilitate transmission of information to outside bodies, including the Agency.

The **general benefits** of using GIS are several:

- provides a digital system for systematic data entry and storage; providing quality control forms part of the process of inputting information, GIS is a highly efficient way of storing huge amounts of data
- provides integrated data layers for easier management; different layers of information can be superimposed simultaneously for a given area
- GIS is a system that allows data to be translated easily into information, such as multi-layered maps or reports, which can support policy-making or planning decisions; if digital 3-D geology were represented in the GIS, it could provide a sound basis for making decisions on underground development plans
- provides an updateable knowledge store; if a key person leaves the organisation, the information is left behind in the GIS and not lost
- GIS is dynamic, versatile and can be interactive with larger modular IT environmental packages
- GIS can be made to be address-linked; the facility to click on a point or a single address to bring up a whole series of different databases is a powerful method to help answer enquiries for that address point
- GIS can be customised for automatic report generation; a programme language can be used to co-ordinate selected information that is spatially related to a given area or point on the map; the output to the printer can be programmed as a series of maps, tables, or diagrams with text
- GIS offers an accessible system for answering customer enquiries; a report writing facility may be required for this function, but once in place, a non-GIS expert can operate the GIS in order to respond to enquiries
- GIS makes it easier to export and import information to or from internal and external bodies; GIS is a way of increasing the efficiency of information transfer
- the GIS databases may have other departmental uses e.g. in Leisure and Education Departments
- GIS is useful when interpreting complex data e.g. the spatial relationships between land use and any soil contaminants present can be explored in GIS making the identification of pollution linkages easier
- provides a sound basis for site risk assessments e.g. the GIS databases can be adapted as input files for modelling in LANDSIM, CONSIM and other model codes
- GIS offers a good visualisation facility for presentations to contractors or to Agency staff and the public
- GIS could be used in training new LA staff; it is possible to draw up a variety of different maps of the area illustrating land use, geology, problem sites etc, for discussion with the newcomer
- GIS can provide overall cost savings for a LA; more efficient management of environmental information will give long-term advantages as less time and therefore fewer staff are required to prepare information for regulatory or enquiry purposes.

The **specific benefits** of GIS are based on the ability to generate easily and quickly a variety of customised thematic maps by interpretations of several individual datasets e.g.

- gas susceptibility maps
- air quality maps

- radon potential maps
- rising groundwater maps
- flood potential maps
- unstable ground maps
- constraint maps for foundation conditions and tunnelling, etc.

Following on from the last two points is the example below in Table 3.1, which sets out the advantages of using GIS when dealing with developments on unstable land. The Planning Policy Guidance Note PPG14: Development on Unstable Land (1990) and Annex 1 Development on Unstable Land: Landslides and Planning (1996), require that the stability of the ground be taken fully into account when deciding a planning application.

Table 3.1. The use of GIS in planning developments on unstable land.

PPG14 and Annex 1 requirements and recommendations	**How GIS can assist developers and planners in meeting the needs of PPG14**
Local authorities to take full account of potential ground instability in determining planning applications.	GIS can be used in the planning process to help in information management and surveys that support the drawing up of structure /development plans and slope stability reports.
Identification of instability hazards in a local authority area of development. There are three broad categories of instability hazard: effects of underground cavities; unstable slopes; and ground compression.	Mapping areas of instability is easily done in GIS and can help in the production of a constraints map.
1. Identification of underground cavities and their effects.	Detailed location maps of sinkholes, solution cavities, undermining shafts and cavities can be displayed *together* in GIS.
2. Identification of unstable slopes and their effects.	Location maps of landslides* (active, dormant and potential), landfalls and landflows can be easily displayed in GIS; areas of mineral extraction beneath slopes can be an added layer; modelling of slope angles and aspects is potentially easy in GIS as is modelling of groundwater impacts.
3. Identification of ground compression and its effects.	Maps showing areas of uncompacted sands, unconsolidated fill, shrink-swell clays and ground heave can be easily viewed in GIS; rising groundwater is a significant controlling factor in some urban areas, and can be modelled in GIS.
Assessment of risks and adverse effects on development and adjoining amenities.	Assessment of landslip potential involving the derivation of ratings for different factors (e.g. slope angle, superficial deposit type and thickness, and groundwater potential), is easily done in GIS where the factors can be combined from different GIS layers (topographical, geological, hydrogeological) for each site area.

Management of risks and application of precautionary measures.	Maps supporting recommendations can be easily generated in GIS.
Effective liaison between the planning and building control authorities.	Easy transfer of digital information and maps is possible if GIS is used.
Answering enquiries.	Easy to do if a report writing function is built into the GIS.

*DETR has a digital National Landslides Database showing the distribution of landslides on county maps at 1:250 000 scale (Jones and Lee, 1994).

3.4 Datasets in the GIS

This Section suggests a useful way of organising the different datasets in a land quality GIS. For land contamination investigations, the **source-pathway-receptor** scheme (see Section 2.3) is a useful way of visualising the structure of the GIS in terms of datasets and layers (see Glossary for definition of terms). A land quality GIS structure is shown in Figure 3.1.

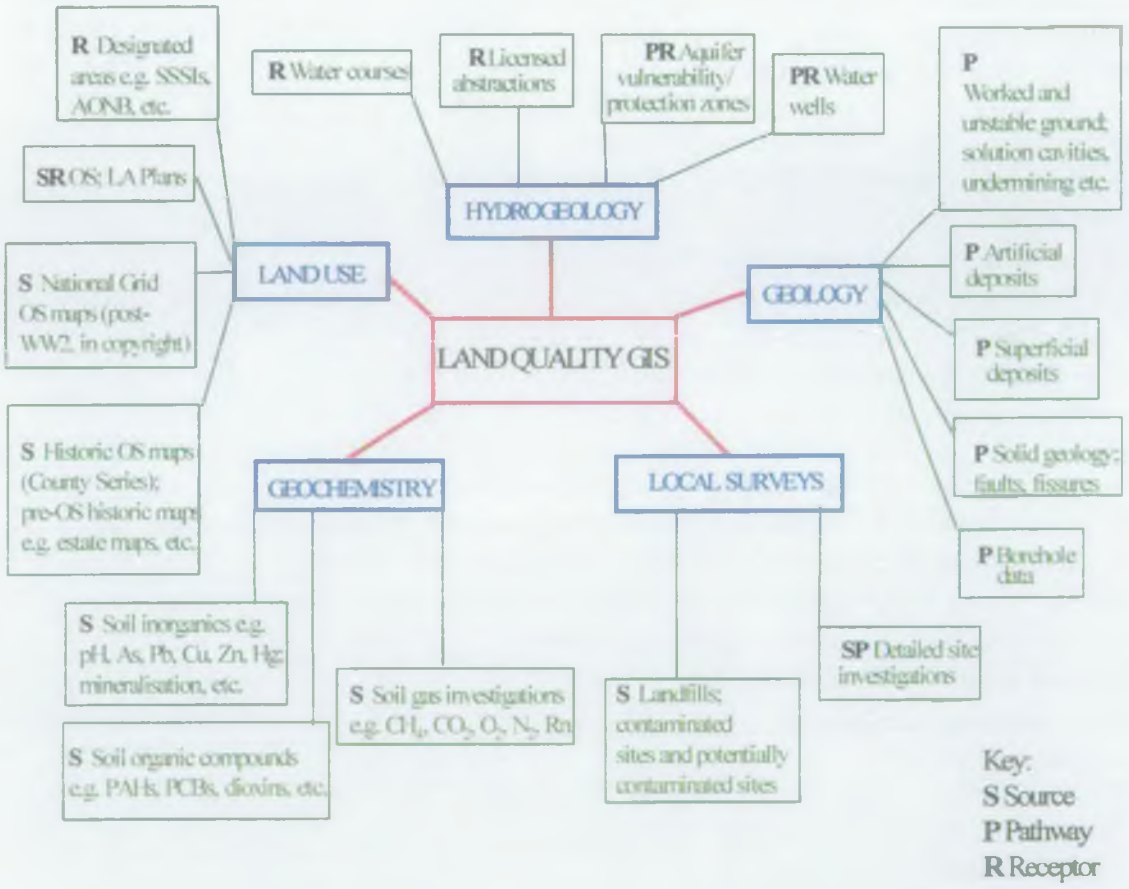

Fig. 3.1 Layers of a Land Quality GIS

Any one of the layers can be selected and displayed within the GIS individually or in combination with other layers. Figure 3.1 also indicates what type of information may be

derived from each layer. Boxes around the different layers indicate either **Source** (identification of actual/potential contaminants), **Pathway** (identification/characterisation of pollutant pathway) or **Receptor** (identification of potential receptors of contaminants). The location of a layer within this scheme helps to indicate the type of information that may be derived from it in order to evaluate a **pollutant linkage**. Where layers fall within two categories the information contained in the layer may contribute to either one or both of the categories.

Data sources for identifying **sources** information include:

- OS land use maps for indicating hazardous sources e.g. landfills, petrol stations, brownfield sites etc; also BGS mineralisation maps and natural contamination maps
- site investigation (SI) reports
- discharge consents
- authorisations for disposals to land
- pollution incidents
- geochemical surveys.

Various reports on potential hazards are available e.g. the DoE's Report 'Survey of Derelict Land in England 1993', which has been superseded by the DETR's 1999 National Land Use Database on brownfield sites; and the Agency's 1999 R&D Technical Report 'UK Sewage Sludge Survey, National Presentation'.

Data sources for identifying **pathways** include:

- groundwater vulnerability maps
- water wells
- surface water course maps ('blue lines')
- soil/drift and made ground maps – properties control run-off and infiltration of contaminants
- geological maps, especially digital interpretations of the sub-surface showing faults
- worked ground; solution cavities, mine shafts and areas of undermining.

Data sources for identifying **receptors** and their protection include:

- OS land use maps for indicating receptors e.g. schools, housing, allotments
- water course maps of controlled waters (rivers, streams, lakes)
- maps of water abstraction wells, including licence-exempt sources
- maps of groundwater source protection zones
- maps of nitrate vulnerable zones
- maps showing designated areas such as SSSIs, AONBs, nature reserves, designated bathing beaches, etc.

3.5 Data management

3.5.1 Introduction

Environmental datasets, in both paper and digital form, are an important and valuable resource. They are often unique and irreplaceable and may be expensive to collect. Appropriate data management is essential to protect this resource and to ensure that maximum benefit is derived from it.

While the datasets may be diverse, it is possible to provide some generic guidelines to help with their management.

3.5.2 Metadata

Metadata is information that describes a dataset. This should include:

- where the data comes from
- how it was collected
- how it has been processed
- quality control procedures used for calibration, validation and verification, quoting relevant standards and procedures or sources as appropriate.
- data dictionary defining each of the attributes (including units), quoting relevant schemes or standards as appropriate
- accuracy, precision , timeliness, missing data
- description of the dataset including spatial and temporal coverage
- ownership, copyright and intellectual property rights of the dataset
- access and users rights (e.g. read only, read/write)
- technical details on how the data should be used
- scale.

Where practical, metadata should follow the guidelines of the National Geospatial Data Framework (DGDF). Information on the NGDF standards can be obtained from the NGDF web site at http://www.ngdf.org.uk/.

An example of metadata is given below for the 1960s land use layer in the GIS developed for the London Borough of Newham. Each layer should have a similar metadata list.

1960s LAND USE LAYER
Authors: R. Leader, A. Ferguson, A. Brown (all from BGS)
Newham Contact: S. Stranders, Environmental Health, Alice Billings House, 2-12 West Ham Lane, London, E15 4SF
Date: 1997
Scale: 1:1 250
Projection: British National Grid
Copyright: OS Copyright
Error Information: some gaps between polygons and overlapping of polygons may occur due to the inherent problems of manually digitising.
Land Use Classification scheme used: the Greater London land use survey 1966, available at the Planning Department in the London Borough of Newham
Comments: the data set was digitised by tracing over paper maps (OS 1:1 250 with added land use classification) held by the Planning Department, Newham. These tracings were brought back to BGS and digitised using the current corporate GIS package. Large residential areas have been digitised as single blocks, which cover all housing areas and intervening roads and shops.

3.5.3 Quality issues – errors and uncertainty

It is important not to assume that any dataset is error-free. Errors in data are almost

unavoidable and it is essential to be able to quantify and assess the errors so that the data can be used to derive valid conclusions. Combining two or more datasets of unknown quality may result in a worthless analysis. Where possible, it is essential to document the quality and reliability of all data by providing appropriate metadata (see above). This will enhance the future value of the data and provide guidance on the reliability and suitability for other users and applications.

3.5.4 Data formats

Databases

Wherever possible, unless project requirements dictate adoption of a specific format, digital data should be stored using standard, widely available, software and their related data formats e.g.:

- Oracle
- Microsoft Access
- Microsoft Excel
- Lotus 1,2,3
- generic .dbf
- ASCII text.

The use of obscure or obsolete data formats should be avoided wherever possible as reformatting data may be difficult, costly or impossible. If no other options are available, ASCII format can be used to transfer between packages.

GIS

Geographical Information systems come in two forms, vector based systems such as ArcView and MapInfo and raster systems such as SPANS and Idrisi. Users will prefer to have a vector-based system as this will be most appropriate for handling the majority of datasets used in land contamination studies. It should be noted that some raster handling capabilities may be required to deal with some datasets. It is advisable to check that the intended system can handle rasters before purchase of either the software or the dataset.

It is not the purpose of this document to specify a particular system. However, the Environment Agency standard GIS is currently ArcView 3.1.

Geo-referencing

The co-ordinate system used for geo-referencing data in a GIS should be the Ordnance Survey British National Grid. Data in postcode format, address point or latitude/longitude can be converted to this system.

When entering co-ordinate information into a spreadsheet or database for future use in a GIS, it is imperative that co-ordinates are entered in a consistent way. Mixing 4-figure, 6-figure (e.g. ST4345, ST430450, ST43004500 etc.) co-ordinates in the same column will cause considerable problems when trying to import data into a GIS. Similarly inconsistent use of spaces, e.g ST 43 45 or ST43 45, will also cause problems and require considerable time to manually edit into a suitable format.

Vector data

Most GIS systems have their own vector data formats but can import and export to a variety of formats e.g.

ArcView – Shape files
ArcInfo – Arcexport (.E00)
MapInfo – MapInfo interchange format, MIF/MID

.DXF format has become a default format that most systems can import/export. This format is typical of CAD systems.

NTF – National transfer format is a standard used by the Ordnance Survey.

Rasters

Data in raster, or gridded format may be part of the GIS data layers. This come in two forms, as raster images, for example a scanned map, or as a raster dataset, for example a digital elevation model (DEM). A scanned raster of a map can only be used as a backdrop and can be displayed in both ArcView and MapInfo. A raster dataset such as a DEM or the ITE Land Cover Map of Great Britain, may be analysed only if the GIS has the functionality to analyse raster data. This requires the Spatial Analyst extension for ArcView and Vertical Mapper for MapInfo.

Raster images or scans can be saved as .tiff files. These are readily imported into most systems and can easily be exported for use in graphic and presentation packages. .tiff images will require some geo-coding for use in a GIS.

Raster datasets can come in a wide variety of formats but ASCII can usually be imported into most systems. Check system specifications before purchasing data.

AGS format

It is worth noting that the ground investigation industry has adopted a standard transfer format for digital data, providing a comprehensive coverage of chemicals and contaminants, as well as geotechnical parameters. Designed and administered by the *Association of Geotechnical and Geoenvironmental Specialists*, it is commonly referred to as the 'AGS format'. See the Web site (www.ags.org.uk/) and click on 'The AGS format' button for more information. The format is essentially comma-delimited ASCII, so as to be independent of different hardware and software systems. Its file structure is similar to that of a relational database, with compound key fields which range from the borehole identifier to an individual test stage on a specimen.

3.5.5 Data media

Suggested data media for acquisition of data (and capacity in MB) from third parties and for data transfer between project teams and other users are, in order of preference:

1 CD-ROM (650MB)
2 1.44 MB 3½□ diskette (1.4MB)
3 FTP (file transfer protocol – digital transfer of data between servers/systems via secure network connections or via www (varies, potentially very large data volumes but depends on system capacities etc.)
4 Various magnetic tape (e.g. DAT) and ZIP drive formats (requires agreement between provider and recipient – some media vulnerable to damage) (+100s MB).

If diskettes or other magnetic media are used, data should be transferred to secure media as

soon as practical.

Depending upon data volumes, direct digital data transfer (e.g. via e-mail or anonymous FTP) may be more appropriate than using intermediate media, but be aware of possible security risks and corruption of data.

Whichever media are used, there is a risk of loss of data through corruption or physical damage to the media. These risks can be minimised through appropriate handling and package and the consequences of lost data eliminated by ensuring that all data are adequately backed up. Where data are transferred electronically via local networks or the www there is are risks that data may be corrupted during transmission (which may not readily be detected) or be accessed, accidentally or deliberately, by third parties. If data are sensitive or confidential appropriate precautions should be taken to minimise the latter risk.

Typical digital map file (depends on compression) sizes are:

OS 1:1 250 Landline .NTF	0.5MB (Maximum 1.5MB)
OS 1:1 250 Landline .DXF	0.8MB (Maximum 3.3MB)
Black and white scan of urban 1:2 500 County Series map	8MB
Coloured scan of similar (but hand-coloured) map	35MB.

3.5.6 Data back-up

The consequences of losing data through not making sufficient or appropriate provision for their back-up are potentially catastrophic in the case of large data collections. In the case of smaller datasets, the consequences are cumulatively serious. Rigid periodic back-up programs will safeguard major, centrally held, digital databases. Provision and support of back-up strategies for digital data stored locally should also be made.

It is recognised that back-up of analogue data collections is less straightforward. Wherever possible, or financially viable, such collections should be "disaster-proofed" by developing duplication strategies, such as micro-filming, digital scanning and photocopying, as appropriate, and by ensuring the separate storage of "master" and second-generation copies.

3.5.7 Data licensing and copyright issues

It is essential that all necessary licences are obtained before use of "third-party" data, equipment and applications. There may be cost and functionality implications of entering into "third-party" licensing agreements.

Copyright is part of the wider field of Intellectual Property Rights (IPR), and is the intellectual property with which most people have some familiarity. Copyright protects the originator of the map or line-work from being plagiarised.

If data are protected by copyright such protection must be respected. Agreement should be reached with the copyright owner about the use of such information. Licence fees may be payable and restrictions applied to the use of information. Such restrictions must be respected. Remember, the product of a project may also benefit from protection.

In essence, IPR issues need to be addressed in all contractual arrangements prior to the start

of a project. This ensures that the ownership of any IPR arising from that project and future exploitation rights are clearly defined and agreed between all parties. This is important even where no exploitable IPR issues are expected to arise from a project.

Customised maps and reports generated by a report-writing facility in the GIS need to be in keeping with the relevant copyrights and also any requirements of the Data Protection Act. An individual's privacy rights may be infringed under the Act if the output report and maps contain environmental information on the person's property and the report and maps are sent to a third party without the property owner's permission.

IPR and the Internet

All data that are made available conditionally (from a non-disclosure agreement to an annual licence payment) should not be accessible directly from the Web without secure protection mechanisms such as password access. The Web is a good place to advertise the existence of data and how to get at it, but less good for conditional self-service.

Publication of maps on the Internet has copyright implications. Permission or licences need to be obtained prior to any intended usage. An Ordnance Survey licence will be necessary for the topographic backdrop of any key maps that are displayed, and for the topographic layer on any GIS system. Likewise a BGS licence will be required for the reproduction of any BGS maps.

3.5.8 Commercial confidentiality

Some of the data that is required by a project may be classified by the data owners as commercially confidential and, while they may be prepared to license its use, they do not wish data to be publicly available. Such confidentiality may also be applicable to such data processed during projects and data suppliers' approval should be sought prior to publication or release of the data. All confidentiality issues should be respected in line with relevant guidelines.

3.5.9 Longer term data management strategy

It is important to recognise that data gathered for a particular programme may have a long-term value not evident at the time of their collection or generation and may be of use for other purposes. Once data have been collected, ongoing data management needs to be considered to ensure the long-term preservation of the data where appropriate. The longer-term data management strategy should include:

- periodic review of all datasets held, and their classification as either:
  - essential (implying a need for provision of long term maintenance);
  - needing care and maintenance (data to be kept safe but not actively managed);
  - or for disposal (no commitment for future data management);
- publicising, to all interested parties, any intention to put at risk or destroy data, before doing so, when it is considered that the cost of keeping datasets outweighs the apparent benefits.

4 DATABASES SUITABLE FOR USE IN GIS

4.1 List of databases

See **Appendix 2** for Tables of the available databases and **Appendix 3** for the addresses of suppliers and notes. Appendix 2 is an inventory of environmental data that could be brought together in a GIS by local authorities and others to help them deal with requirements of planning, development and land contamination issues. Particular emphasis is placed on digital data. The inventory is useful for an initial search and collation of information. Much of the information requires expert interpretation that might be carried out in-house or by consultants. Remote sensing data and imagery have not been included, as they generally require highly skilled interpretation. Aerial photographs cover most of Britain since 1946, and can be useful for determining the boundaries of old quarries and landfills etc.

Essential information that should be examined in an initial search is tabulated in Appendix 2. More detailed information, which might be consulted in a secondary search, is listed in separate Tables. Those data that are wholly or partly available in digital form are indicated in the Tables. All this information is divided into nine topics:

- Land Use
- Natural Contamination
- Geochemistry Surveys of Water and Soils
- Geology
- Undermining and Natural Underground Cavities
- Hydrology
- Topography
- Hydrogeology
- Conservation Data.

In Appendix 3 information is given, where possible, on:

- availability
- supplier and/or owner of data
- format
- extent of coverage
- scale
- cost.

An indication is given where data are available in digital form, but where digital data are not available alternative sources are given. One factor that is of concern is data quality. Ideally the database fields would be validated or have some flag to indicate quality or uncertainties.

The scale of available data is an important issue. Generally, data are available to satisfy three principal levels of usage: strategic (national or regional), local and site specific. A wide range of data with national coverage can be used at the strategic level but there are few national datasets with sufficient detail to be applicable directly at the local level, and even fewer at the site specific level. For example, at a site-specific level, national maps on undermining collated at the 1:250 000 scale are too imprecise. They can only be used to give a general appreciation of the likelihood of mining having taken place in the area.

Table 4.1 Scales of some readily available digital datasets.

Selected digital datasets	Scales
OS digital raster maps; OS Land-Line®	1:50 000 and 1:10 000; 1:1250 urban; 1:2500 rural; 1:10 000 moors
BGS Geological maps, solid and drift	1:250 000 seamless national coverage; 1:50 000 planned national coverage; 1:10 000 limited coverage
BGS MINGOL Minerals Database	1:250 000
Institute of Hydrology water courses	1:50 000
OS digital terrain models, raster	1:10 000 and 1:50 000
Environment Agency Groundwater Source Protection maps	1:50 000 polygons on the Environment Agency's WWW site
Stationery Office Groundwater Vulnerability maps	1:100 000
Environment Agency 'Section 24' maps on flooding	1:50 000
MAFF Nitrate Vulnerable Zone maps	1:25 000
DETR National Landslides Database	1:250 000 on county plans
English Nature SSSI, NNRs, SACs, SPAs and Ramsar sites (see Glossary)	1:10 000

Much of the information referred to in Appendix 3 can be consulted in the appropriate libraries or offices of national organisations.

The scanning of hard copy maps for use in a GIS database may incur copyright fees. These will depend on individual arrangements with the Ordnance Survey and also with the organisation which added value to the map e.g. BGS, the Institute of Hydrology, etc. The GIS-builder is advised to contact the relevant organisation regarding the latest information on cost, availability and formats.

4.2 Scales

Automatic mechanisms can be built into a GIS to prevent information at small scales e.g. 1:250 000, being viewed at much larger scales e.g. 1:1250, where the information will become unfit for use, either by appearing fuzzy or having linework that does not match up with the OS topographic backdrop. If such an automatic mechanism does not apply in the GIS, care must be used to ensure that the scales are appropriate and fit for purpose. A visual illustration of the problem is shown in Figure 6.9 in Section 6.1.7.

Table 4.1 below shows the scales of some digital environmental datasets that are readily available and which offer mainly national coverage.

5 BUILDING A LAND QUALITY GIS

The purpose of this Section is to highlight the stages needed for building and implementing a land quality GIS. The key to building an effective land quality GIS is good planning. A

thinking stage is needed first to decide what questions the GIS needs to answer and what formats these answers should be in.

5.1 Stepwise guide to building and implementing a customised GIS

It is possible to identify a number of key development stages from the BGS experience of implementing a fully customised Contaminated Land GIS for the London Borough of Newham. These stages are set out below:

1. User interviews (objective setting and planning)
2. Design of the GIS
3. Collation of existing digital datasets
4. Data capture of non-digital datasets
5. GIS construction
6. GIS customisation
7. Installation and training
8. Support and maintenance
9. Ongoing development

Each of these stages is discussed in detail below.

User interviews (objective setting and planning)

Early discussions between the developers of the system and its potential users are vital for the success of the GIS project. It is important that before the design stage takes place:

- the developers understand the type of queries that are currently answered so that the system can be designed to answer more effectively these queries;
- the potential users of the system understand a little about what GIS can do so that they are able to participate in the design of the system.

Design of the GIS

The design of the GIS is a joint process between the developers of a system and its potential users. It is composed of:

- identifying the datasets that would make up the final system
- deciding upon the customisation of the GIS i.e. what extra functionality, such as report writing and risk assessment, are required. How the user would interact with this new functionality is also defined e.g. for a report generator this would include how the user selects a site, the topics included in the report, and the appearance of the final report.
- the choice of which GIS package to use.

Getting the design of the system right at this stage is critical. Both the developers and users must be satisfied with how the final product will work. A bad design will result in a lot of wasted effort when problems become apparent at a later stage. This highlights the need for good planning and close liaison between the developer and the user.

If the users are constrained to use a particular GIS package either through corporate policy or because a package has already been purchased, then the design of the system is limited to what can be achieved using that software. However, if the choice of GIS package is open, then the system should be designed first before choosing the GIS package that best implements this design.

Collation of existing digital datasets

A number of datasets identified in the design phase of the project will already exist in a digital format. In all cases, datasets are collated taking into account:

- scales; the scale of all datasets used must be appropriate for the use for which they are intended (i.e. datasets of vastly different scales should not be mixed);
- quality; the dataset may or may not be annotated or attributed with the necessary text information; it is advisable to check before purchase;
- formats, an issue dealt with below;
- copyright; it is important that the copyright of data is adhered to e.g. the legality of passing on data in the form of a map should be investigated; initially, the copyright terms may only refer to internal usage of the dataset, but if a commercial use is required later, a change in the copyright agreement terms may be expected.

Data will arrive in a number of formats, and thus some data conversion is necessary e.g. OS data may arrive in NTF format, which needs to be converted into a compatible format before being incorporated into an ArcView GIS. To convert between NTF and ArcView requires a separate software package from the makers of ArcView (ESRI), called MapManager. Sometimes this conversion can be straightforward (e.g. moving datasets from a MapInfo format to ArcView format), but the GIS developer needs to be aware that this may not always be the case.

Data capture of non-digital datasets

In a number of cases, data may not exist in a digital format e.g. the historical land use information is often only available as paper maps. Thus, either a substantial amount of time must be set aside for the labour intensive task of digitising these datasets, or money be made available to purchase the datasets from e.g. Landmark, Catalytic Data, etc.

It is important when creating such digital datasets to provide metadata about the dataset i.e. information such as scale, projection, date created, error information, etc. In this way, future users of the data can assess its fitness for purpose for different tasks.

GIS construction

Once all of the datasets exist in a digital format, they are combined in the GIS package. Using ArcView this is relatively straightforward. Some care must be taken to ensure that the colours used in each layer are not confusing e.g. that water should be coloured blue, and also that layers which need to be shown together are coloured appropriately. For example, the solid geology and artificial deposit polygons can be made transparent so that they can be displayed on top of the superficial deposits.

GIS customisation

Not all GIS packages contain a development language, which can be used to customise the product. If a project is tied to such a GIS package, customisation will not be possible. Where customisation of the GIS is possible, the expertise of a GIS specialist will be needed. A customisation may involve the following:

- addition of a general report writing facility;
- addition of a risk assessment mechanism to prioritise contaminated and potentially contaminated sites for further study;
- improvement of the user interface e.g. the addition of a gazetteer to allow easier site identification.

For ArcView, customisation is implemented using Avenue (see Glossary). This process can be potentially time consuming and expensive. Code developed from scratch can be error prone until all of the new features are tested extensively by the developers and users. However, once completed, the resultant report writing facility can significantly speed up the processing of day-to-day site queries.

Some legal issues may pertain to the reports generated by a report writing facility e.g. copyright and a possible legal point under the Data Protection Act. An individual's privacy rights may be infringed under the Act if the output report contains environmental information on the person's property and the report is sent to a third party without the property owner's permission.

Installation and training

The next stage is to install the GIS and to train the staff in its use. Training is often an underestimated phase of the project, but it is vital if users are going to get the most out of the system. Training should cover not only the customised functionality of the GIS, but also the basic functionality of the GIS package itself.

Support and maintenance

There will undoubtedly be problems and issues arising from the use of the GIS after its installation. These may range from the package crashing to simple GIS questions from the users. It is therefore important that continued support is given to the users. As time goes by, the users will become more competent and the software becomes more reliable, and the level of support from the GIS developer will drop significantly.

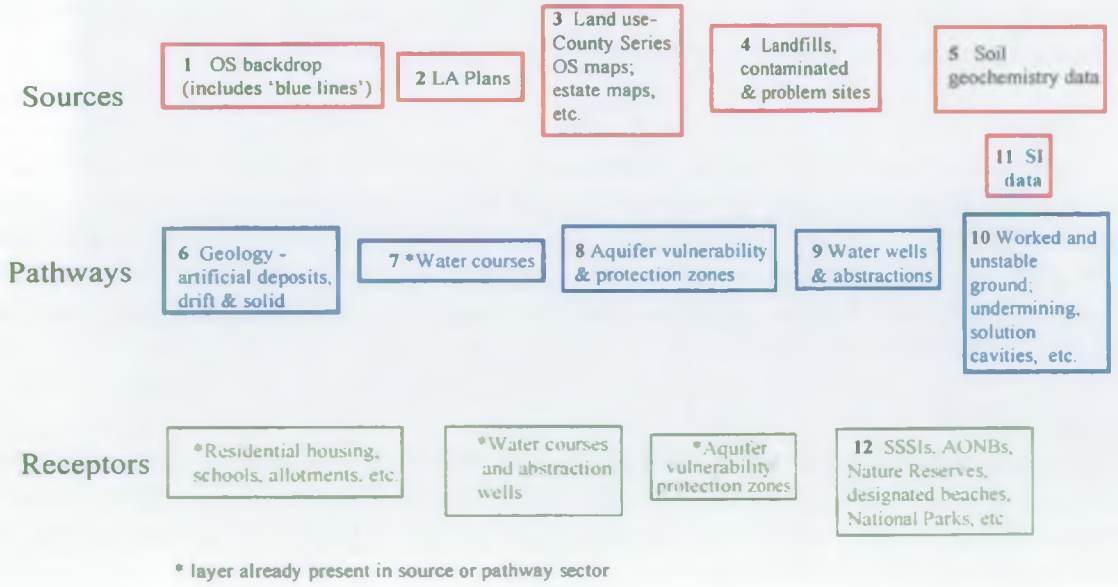

Fig. 5.1 Idealised steps to build a Land Quality GIS

Ongoing development

Additional datasets and functions can be added to the GIS to suit specific purposes. Data updates will always be required e.g. the SSSIs are updated every month by English Nature, and other datasets obtainable from the Environment Agency, e.g. Groundwater Source Protection Maps, will also need updating.

The block diagram, Figure 5.1 below, summarises the idealised steps that would be needed to build a land quality GIS. It should be noted that in practice the datasets are often inserted as layers as and when they become available.

6 GIS CASE STUDIES

Three worked examples of applying GIS and digital environmental data in local authority areas are presented here with a stepwise guide for each case. The three LAs are the East Riding of Yorkshire Council, Leicester City Council and the London Borough of Newham. The case studies are described in an order that reflects an increasing degree of GIS development, with Newham having the most well-developed GIS of the three examples. These case studies will show the steps required and the possible problems faced by a user when setting up a GIS system for managing land quality issues, including land contamination.

6.1 GIS for the East Riding of Yorkshire

The objectives of this study were to build a preliminary ArcView GIS covering the East Riding area and to describe the steps taken to build the preliminary GIS version. This case study demonstrates how to start up a land quality GIS more or less from scratch.

6.1.1 Introduction

The East Riding of Yorkshire Council (ERYC) has authority over a predominantly rural area covering 241 641 hectares or 2 416 sq km, with a population of 310 000. The main population centres include Goole, an important inland port, Bridlington, a popular seaside resort, and the historic town of Beverley (Figure 6.1). [It should be noted that Figures 6.1 to 6.9 were downloaded from the preliminary ERYC GIS implemented under this project. Attribute details, such as scale-bars and the north direction indicator, are therefore missing. Despite this, the Figures are useful in illustrating some points of issue.] The north east coastline and some of the Yorkshire Wolds form part of a thriving tourist industry. It is the largest of the new unitary authorities that were established in 1996 during local government reorganisation.

The following sections detail the steps undertaken to create a GIS from first principles for the ERYC, a council with little previous knowledge of GIS. ERYC were using ArcView 3.1 for air quality modelling using Atmospheric Dispersion Modelling System (ADMS Urban). Therefore staff had some basic knowledge of GIS and its application. Broadly, the steps outlined in Section 5.1 of this report were followed. The account concludes by discussing some of the key issues encountered during the work. The knowledge gained should assist other local authorities and land quality managers considering the use of GIS for managing

environmental data.

Figure 6.1. East Riding boundary map with some place names added.

6.1.2 User interviews

The GIS developer (BGS) and council staff met in the Public Protection & Housing Services office in Goole. The source-pathway-receptor concept for identifying and prioritising contaminated land were explained by reference to the CLR6 document (DoE, 1995). An organogram of the original Newham GIS structure was also shown, to illustrate the choice of datasets available which could form the basis of a GIS.

ERYC staff had many aspirations for the GIS and these were discussed at the various meetings held with BGS and ERYC staff throughout the pilot study. The extensive East Riding area means that large quantities of information are required to be stored, and therefore a user-friendly digital system rather than a paper system would ensure quick retrieval and an easier means of managing the information.

Previously, the Cambridge Environmental Research Council (CERC) had worked with staff in the ERYC Public Protection Department, advising them on approaches to air pollution dispersal monitoring. Since the results of such monitoring were to be incorporated in their GIS, ArcView was chosen by ERYC staff as it was well-suited to this type of work, in

addition to land contamination studies.

The type of PC for running the new GIS was discussed. Particularly useful is a Pentium II machine running at 300 MHz or higher, with a larger than average screen size (19 or 21"), adequate hard-drive space (> 6.4 GB), and at least 128 MB of RAM. In addition to a standard CD-ROM drive, a CD-writer or other means of creating backup copies of the GIS will be required. Since it is often helpful to include pictorial images of a site into a report, access to a digital camera would enhance the usefulness of the GIS.

6.1.3 Design of the GIS

ERYC staff wanted to store data from their Part A and B industrial processes files in a layer on the GIS. Other datasets such as geology, historical maps, water courses, landfills and borehole data were also noted for inclusion.

One of the advantages of using GIS to collate environmental data is that it can be tailored to the specific needs of the local authority. By selecting from the considerable variety of data sources available (see Appendix 2), and/or converting paper records to a suitable format, additional datasets can easily be added in the future e.g. airfields, petrol stations, 'local knowledge', etc. Other datasets worth considering for inclusion are the Agency's indicative flood risk maps (recently supplied to each LA on a CD-ROM) and the digitisation of the 1935 historical county series maps for land use at that time.

A dataset can be linked to any other in the GIS to provide the user with a wide variety of information about a site. Bearing in mind the source-pathway-target concept, the ability to view combinations of layers (called 'themes' in ArcView) is particularly useful for assessing planning applications, and identifying contaminated land, including the issue of remediation.

Since the main aim was to show how to create a GIS from first principles, the ERYC GIS was demonstrated at each face-to-face meeting whilst it was under construction. This was important as it provided ERYC staff with an idea of the different steps involved, showed them how useful such a system could be and enabled them to continue populating their GIS with additional datasets once the case study was completed. ERYC staff used the demonstrations as a means to discuss future themes for the GIS and also presented ideas to BGS for modification of the GIS while under construction.

The demonstrations were necessary as some of the datasets, e.g. the entire County Series historical maps, were too large to incorporate into the GIS within the time constraints of the case study. Use of Access databases, and other file formats, to collate paper records prior to loading on the GIS were also discussed.

6.1.4 Data capture of non-digital datasets

Since the ERYC boundary would form the basis of the GIS, and all subsequent layers would be 'cropped' to it, this was the first dataset loaded into the ERYC GIS 'project' in ArcView. The boundary was digitised using AutoCAD software from a 1:100 000 scale map supplied by the council. An example of cropping is given in Figures 6.2 and 6.3 below.

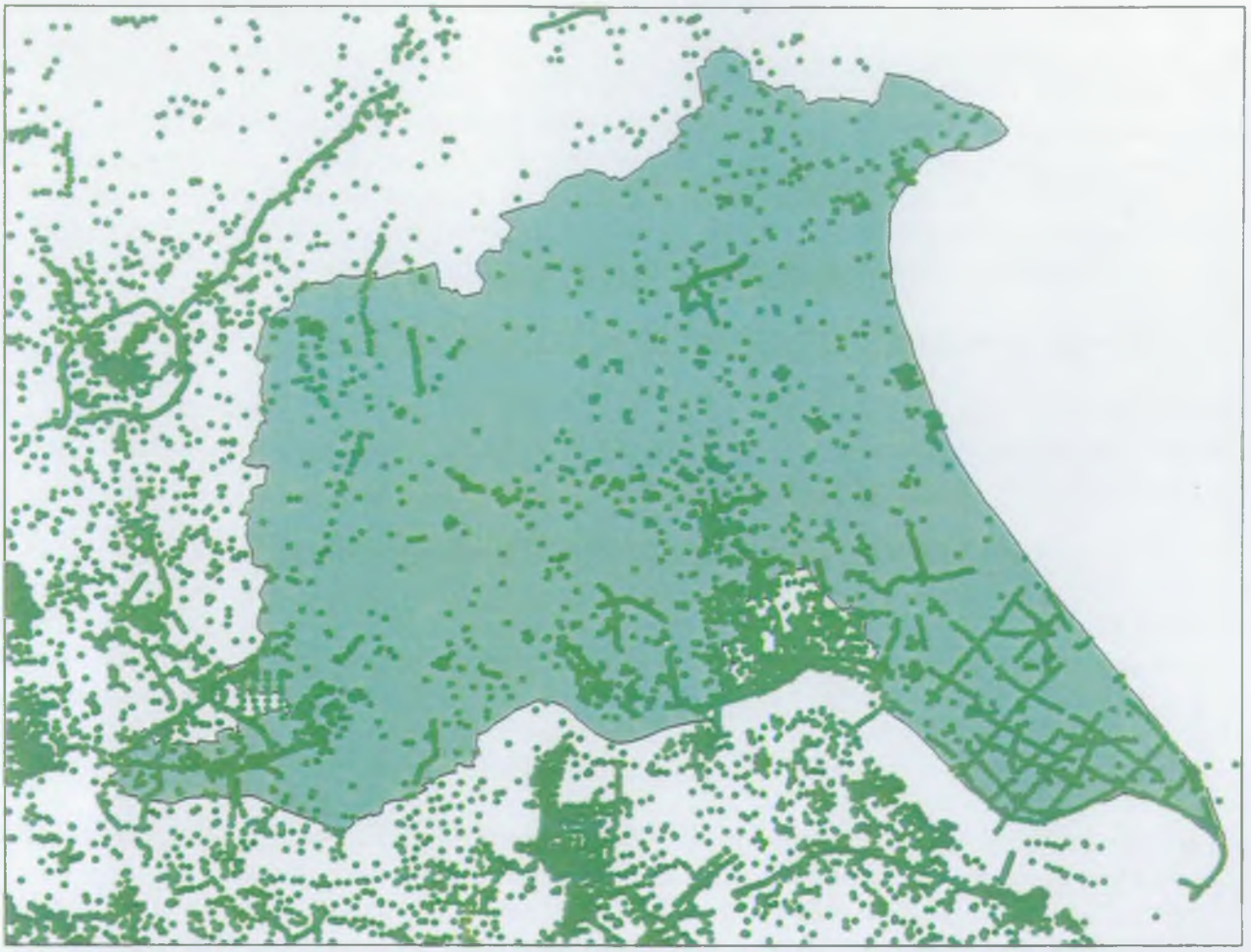

Figure 6.2 Part of the BGS UK onshore borehole dataset before being cropped to the East Riding boundary.

Cropping was achieved using the 'Select by Theme' function in ArcView. This facility selects all the boreholes which fall inside the East Riding boundary, and exports the data to a new file.

Sample entries from the Part A and B industrial processes files were also transferred to the GIS as a unique layer. This dataset was originally supplied as a stand-alone table in Microsoft Word, which does not convert easily into Microsoft Excel. Manually entering two complete records from the data into a new Excel file, and saving in .dbf (dBASEIV) format ensured it was compatible with ArcView. The remaining Part A and B industrial processes data will also require processing in this way, a time-consuming step which illustrates the need for prior planning when deciding the format for converting non-digital datasets. (It is worth noting here that information on the Part A and B processes can be found in the 'What's In Your Backyard' section of the Environment Agency's Web site. The user is prompted to use a postcode, which draws up a list of all the processes registered within the area.)

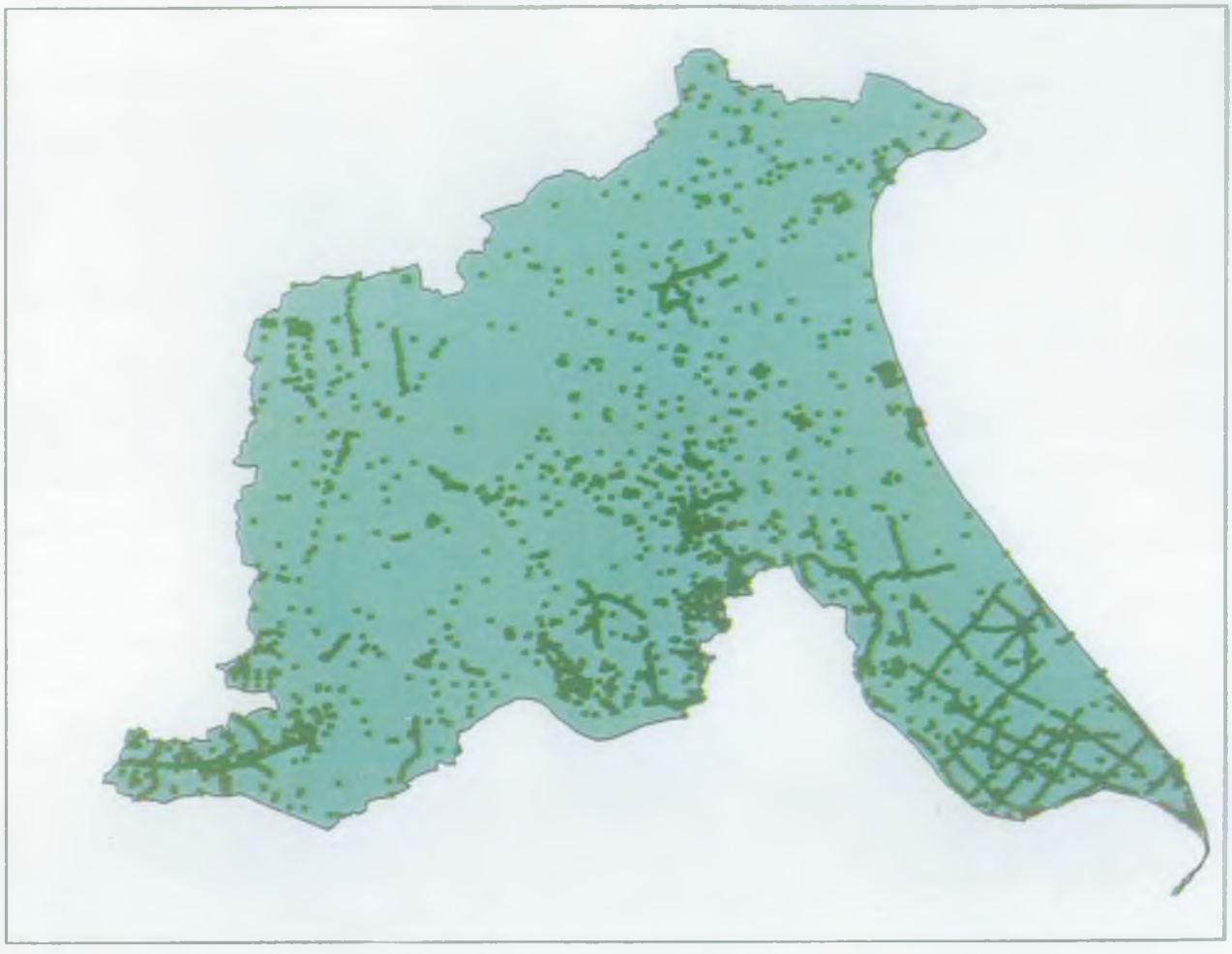

Figure 6.3. BGS borehole dataset after cropping to the East Riding boundary.

6.1.5 Collation of existing digital datasets

Populating the GIS with data already in ArcView shape file format was relatively quick and easy. These data included pre-1972 landfills, water boreholes, onshore boreholes, groundwater vulnerability, water abstractions, and the English Nature datasets. The post-1972 landfill dataset required a short conversion step before they could be loaded on the GIS. Remaining datasets produced some problems that took time to resolve. However, once the correct method was established, conversion and loading were straightforward, despite often involving a number of steps.

For example, the twenty Ordnance Survey Land-Line® maps at 1:50 000 scale supplied in .tiff file format had to be geo-referenced, i.e. located geographically by specifying the co-ordinates of the map corners (see Section 3.5.4), before they could be loaded into ArcView. County Series historical maps were also obtained as .tiff files, but were not projected in the same way as current maps with National Grid coordinates. The process of correction by rotating the image is quite complicated and slow, requiring either ArcInfo, a GIS-package for mainframe computers, workstations and high-spec PCs, or Intergraph, a specialist drawing package. Since most local authorities would not have access to these applications,

PaintShopPro®[1] was used as an alternative. After calculating the degree of rotation and inputting the results into PaintShopPro®, the images were rotated before being treated like the OS maps above.

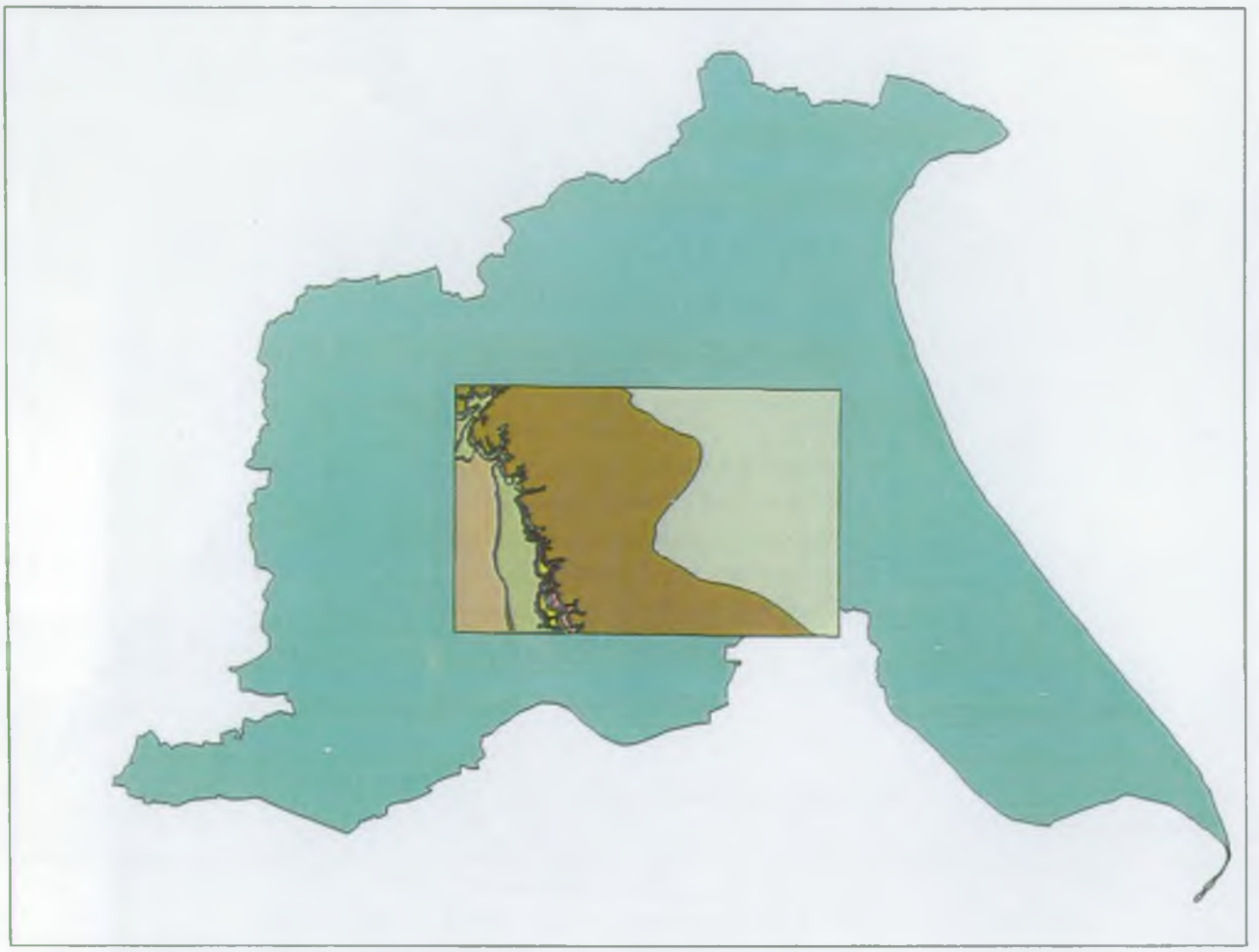

Figure 6.4 Beverley area geology; BGS Sheet 72 at 1:50 000.

The water course or 'blue line' dataset, purchased under licence from the Institute of Hydrology, was delivered in compressed file format. The usual methods for loading datasets were found to be unsatisfactory. Thus ArcView's programming language Avenue (see Glossary), was employed to write a script which changed them into shape files ready for loading into the ERYC GIS.

The East Riding area is covered by 10 different BGS 1:50 000 sheets for the solid and drift geology. Sheet 72 for the Beverley area was digitised in ArcView shapefile format allowing the solid and drift datasets to be loaded into the ERYC GIS without difficulty (see Figure 6.4 above). The remaining sheets for the East Riding area are being digitised under the current core BGS digital mapping programme.

During the case study, staff at the ERYC collated information on 345 landfill sites into an Access database table. This was easily loaded into ArcView after being saved as .dbf file

[1] PaintShopPro® is a widely available graphics package.

format in Microsoft Excel. After loading the file, the data were displayed as points on the map.

Layers consisting of more than one image, such as the Land-Line® or historical datasets, were 'joined' into one theme by creating an image catalogue (see Glossary) in ArcView. An image catalogue is useful for combining a number of images into one theme e.g. there were six 1st Series historical maps in the ERYC GIS. The spatial extent of each map was obtained by examining the theme's properties and noting the Left Bottom and Right Top coordinates. These data were added to a new table in ArcView, the image catalogue (Table 6.1). The image catalogue uses specific terms for the coordinates - XMIN, YMIN and XMAX, YMAX respectively. Along with the full directory path name of each map, these data define the image catalogue for this series of maps.

After saving as a .dbf file, and loading in the ERYC GIS, the table becomes a theme in itself, which 'points' to the map location, thus enabling the individual images to be deleted.

Table 6.1 The image catalogue .dbf file for the 1st Series historical maps.

IMAGE	XMIN	YMIN	XMAX	YMAX
D:\eastriding\erycgis\ data\history\pspv231.tif	499564.00000	440836.09815	501997.41960	442474.99995
D:\eastriding\erycgis\ data\history\pspv241.tif	501977.00005	440866.10655	504409.96275	442506.00005
D:\eastriding\erycgis\ data\history\pspv271.tif	499585.00000	439226.42880	502018.67920	440866.00000
D:\eastriding\erycgis\ data\history\pspv281.tif	501998.00000	439257.60400	504432.10400	440897.00000
D:\eastriding\erycgis\ data\history\pspv2111.tif	499606.00000	437576.83200	502039.89160	439257.00000
D:\eastriding\erycgis\ data\history\pspv2121.tif	502019.00000	437648.10595	504452.72180	439288.00005

When loaded into the ERYC GIS, the entire layer can be displayed as a single image by 'pointing' to the original ones. This facility is useful, particularly for a council such as ERYC, whose area has a large geographical extent.

6.1.6 GIS construction

The GIS was constructed by loading layers into ArcView as they became available, and after the appropriate preparatory work had been completed (Sections 6.1.4 and 6.1.5). Many of the layers loaded contained data from outside the ERYC boundary. To ensure the GIS only contained data relevant to ERYC, such layers were 'cropped' to the boundary in ArcView.

Because of the large area covered by the East Riding, two sections of the National Grid labelling system are relevant. These are prefixed with the letters SE and TA. English Nature supply their datasets according to their National Grid pre-fix. So for example, the Sites of Special Scientific Interest (SSSI) layer was actually two separate datasets, which were later joined to create one dataset. This is illustrated in Figures 6.5, 6.6, 6.7 and 6.8.

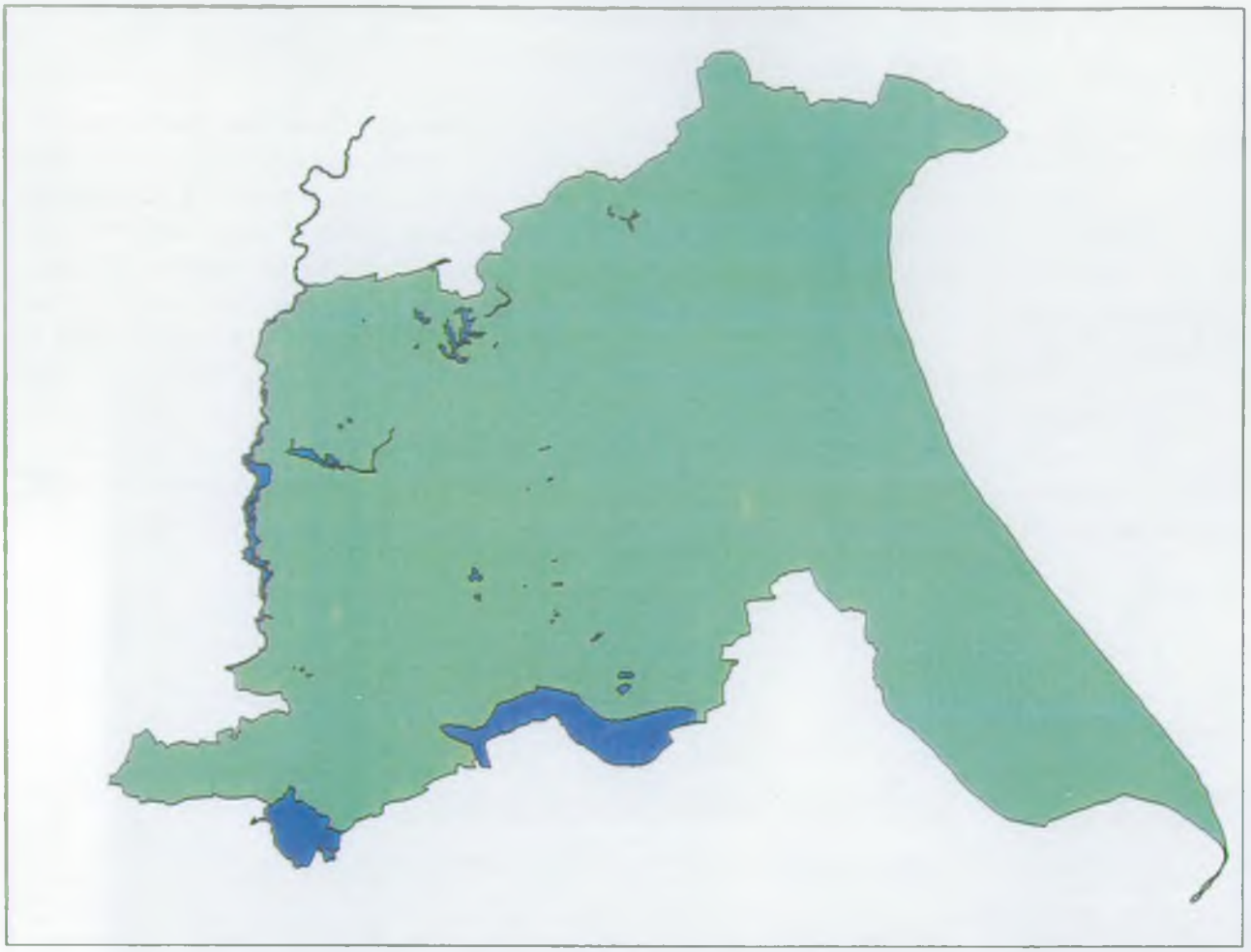

Figure 6.5. SSSIs contained on the SE dataset from English Nature.

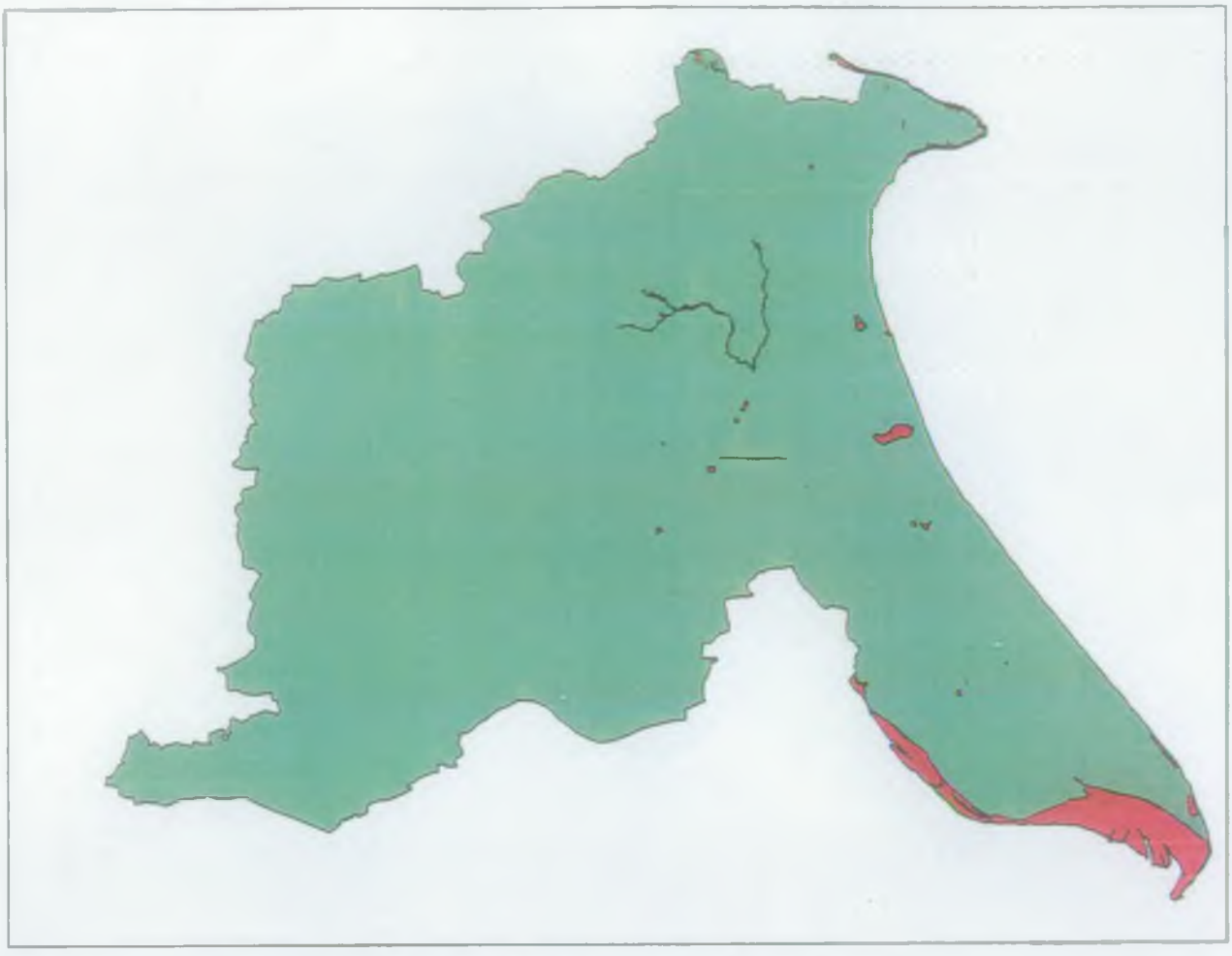

Figure 6.6. SSSIs contained on the TA dataset from English Nature.

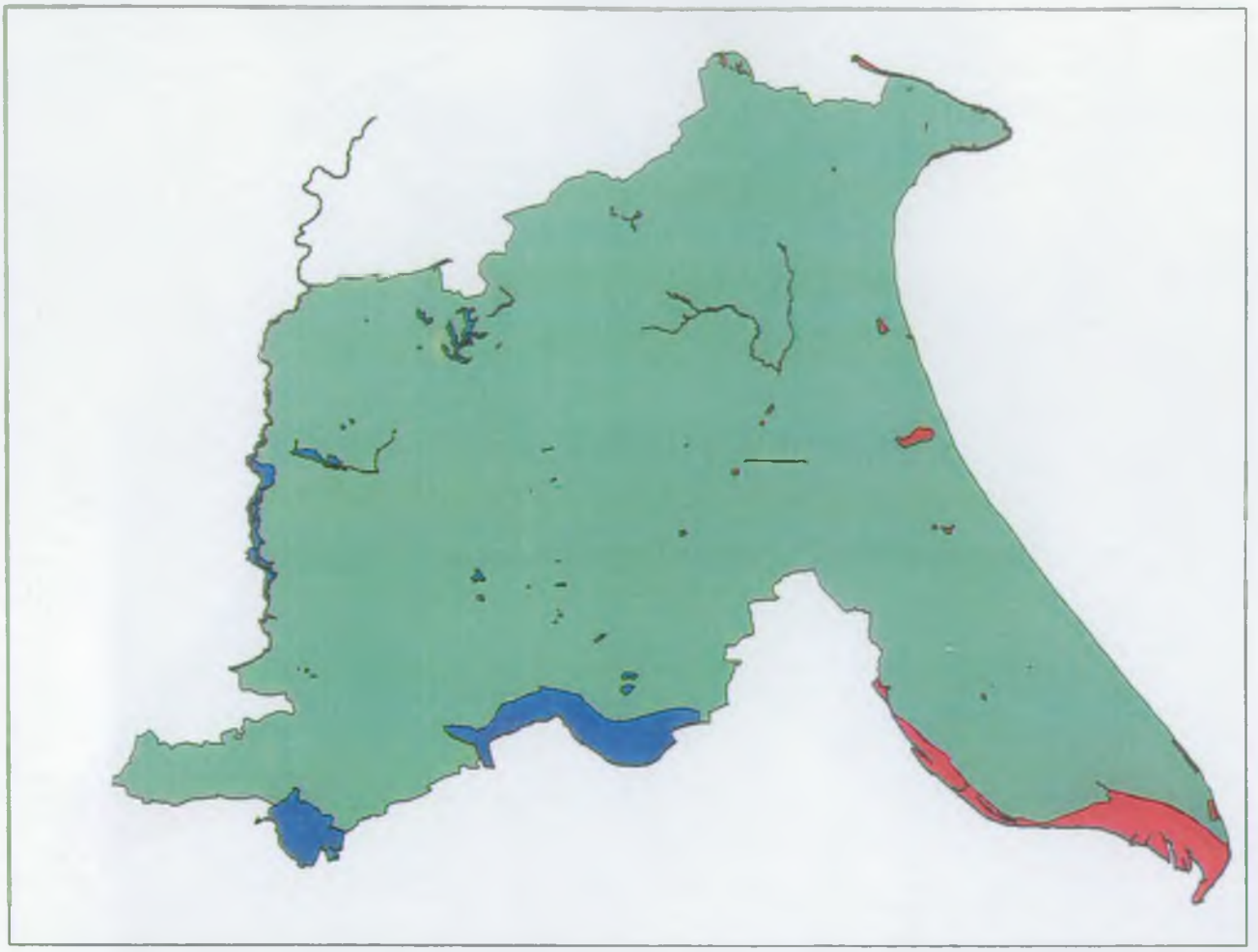

Figure 6.7 SE and TA SSSI datasets (from English Nature) displayed simultaneously.

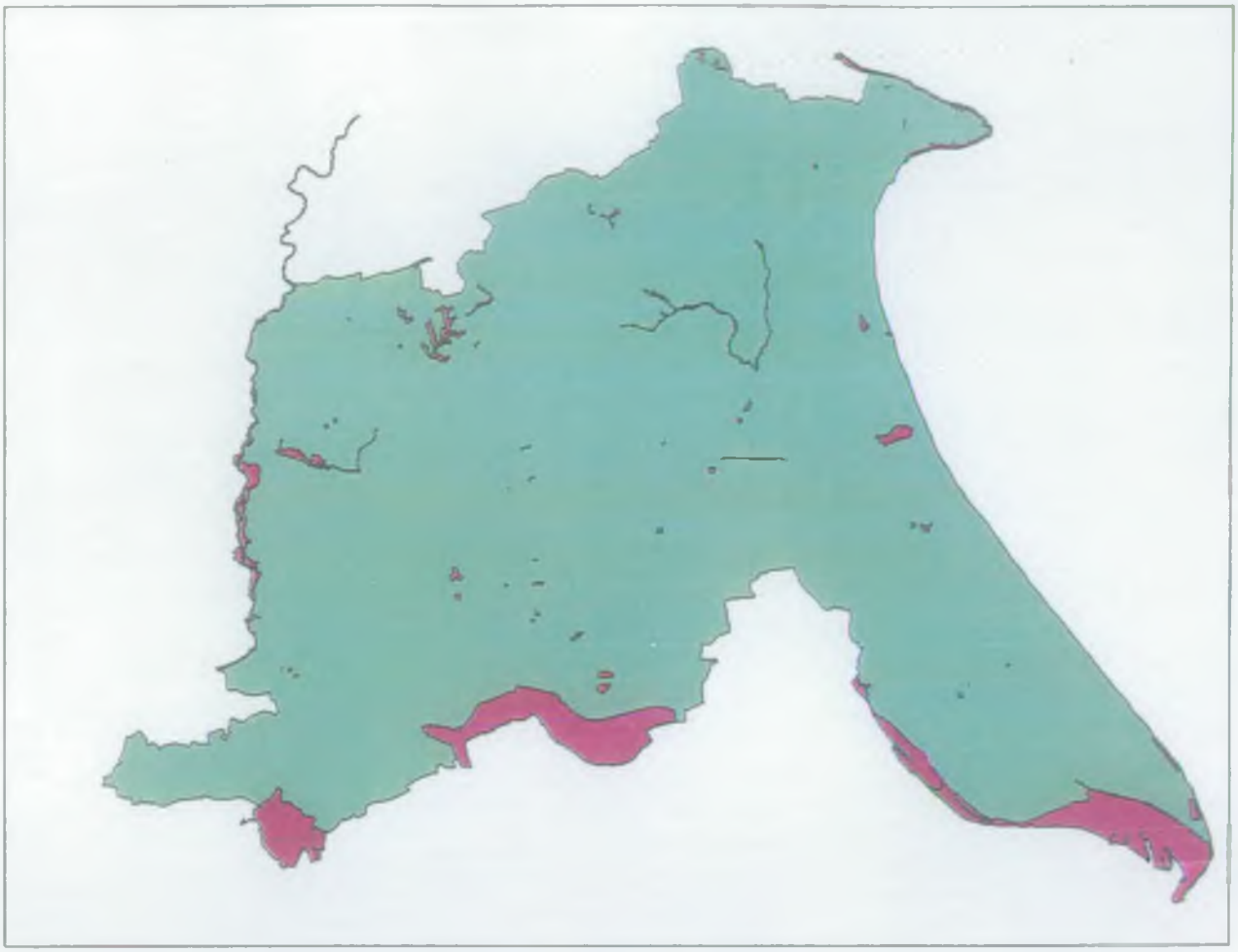

Figure 6.8 SE and TA SSSI datasets (from English Nature) combined.

This merger was achieved using the GeoProcessing wizard extension in ArcView. This facility allows two themes to be merged and exported to a new file.

ArcView automatically selects a legend for each dataset that is loaded. Occasionally the choice was unsuitable, and required changing to ensure that the common combinations of datasets did not conflict when displayed simultaneously. This is an iterative process depending on the combination of layers chosen for display. However, altering a theme's legend in ArcView is quick and simple.

Alternatively, a legend file can be created in order to store the colours and attributes for a standard or other dataset. This can be loaded instead of having to manually re-define the theme's automatically assigned legend.

Table 6.2 below gives the layers loaded in the ERYC GIS at the completion of this study.

Table 6.2 List of layers initially loaded into the ERYC GIS.

Dataset	Source
Solid geology	Solid geology from the BGS 1:50K digital dataset
Superficial deposits	Superficial deposits from BGS 1:50K digital dataset
Boreholes	Boreholes from the BGS digital borehole database
Water courses	Rivers and canals taken from the Institute of Hydrology digital dataset, converted by BGS
Water boreholes	Water wells from the BGS digital water well database
Licenced water abstractions	Water abstractions taken from the Environment Agency digital dataset, converted by BGS
Groundwater vulnerability	Groundwater (aquifer) classification taken from the Environment Agency digital dataset, converted by BGS
Sites of Special Scientific Interest	SSSIs (see Glossary) from the English Nature digital dataset, converted by BGS
Special Protection Areas	SPAs (see Glossary) from the English Nature digital dataset, converted by BGS
Special Areas of Conservation	SACs (see Glossary) from the English Nature digital dataset, converted by BGS
Ramsar sites	Ramsar sites (see Glossary) from the English Nature digital dataset, converted by BGS
National Nature Reserves	NNRs (see Glossary) from the English Nature digital dataset, converted by BGS
East Riding boundary*	Digitised and converted into ArcView format by BGS
Pre-1972 landfill sites	Landfill sites taken from the BGS digital dataset
Post-1972 landfill sites	Landfill sites taken from the Environment Agency digital dataset, converted by BGS
Landfill sites database	Access data provided by ERYC, converted by BGS
Part A and B industrial processes	Excel data provided by ERYC, digitised and converted by BGS
Historical maps of Beverley	Digital versions of maps provided by ERYC, converted by BGS
Digital OS Land-Line® maps	Digital versions of maps provided by ERYC, converted by BGS

* Non-digital dataset

6.1.7 Issues encountered

In the course of constructing the preliminary GIS, a number of issues arose. The following brief overview should aid land quality GIS-builders in the process of selecting and loading data into a GIS.

Being a large area, some of the datasets for the East Riding are correspondingly large, with potential difficulties of cost and availability. Purchasing the relevant datasets can be more expensive and take longer for delivery than for a small urban area e.g. water course data are charged per 100 km^2 irrespective of the amount of data contained within the square.

Digital versions of the solid and drift geology are not yet available from BGS at 1:50 000 scale for the whole of the UK, so an authority could find its area is one of those awaiting

digitisation. For the East Riding, only the Beverley and Selby 1:50 000 sheets had been digitised during the period of this project. The Beverley tile was installed without trouble, but attempts to join it with the adjacent Selby tile highlighted some difficulties e.g. the polygon line work, which marks the boundaries of rock units, did not match everywhere across the adjoining edge, and there were problems with colour matching. BGS will carry out further priority digitisation work to resolve these problems, with the aim of creating a seamless 1:50 000 geology layer for the whole East Riding area.

A particularly difficult problem concerned the file formats in which certain digital datasets were supplied, and thus the length of time required to convert them into an ArcView compatible format. As experience in using and manipulating data for ArcView increases, this problem will decrease.

The data obtained should benefit the tasks that the GIS has been created to perform, such as identifying contaminated land and the sensitive areas around it. The range of information attached to datasets varies greatly. Some provide additional data that is easily identified in ArcView, but others are not annotated in this way, containing a line, point or polygon for which no additional information is available. The water course dataset from the Institute of Hydrology is unannotated. While providing a geographically accurate location, lack of annotation may mean the user is less able to classify the site correctly without further work.

It is important to be aware that overlaying a present-day map with a historical one will often show minor inaccuracies in the location of roads or other features. The errors are particularly apparent if displaying small-scale maps (e.g. 1:50 000) simultaneously with large-scale ones (e.g. 1:2 500). Depending on the investigation, this could be significant. An example is shown in Figure 6.9.

The green areas on Figure 6.9 are from the 1:2 500 1st Series historical maps, while all other colours are from the Ordnance Survey 1:50 000 base map. In order to see the text on the 1:2 500 map, detail on the 1:50 000 map is lost. Besides illustrating possible errors encountered when comparing maps of different scale, Figure 6.9 also shows up the fact that they were created at different times.

Some of the datasets are subject to various copyright regulations or are simply not available e.g. some of the BGS datasets are for internal BGS use only, although this situation may change in the future. Other datasets require a licence to be purchased, which generally must be renewed on an annual basis, a point worth considering at the planning stage of the GIS so that future costs are not overlooked.

Purchase of digital historical data can be a considerable outlay, particularly for those local authorities which have charge over large areas. However, if staff-time is not a problem, using an A0 scanner could reduce the cost of digitising historical maps.

Finally, while collecting and loading data into a GIS is very useful, local authority staff may not have sufficient experience or knowledge to interpret the data, particularly if they are new to this type of work.

Figure 6.9. An illustration of the problem of scale mismatch. ©Crown Copyright. All rights reserved.

6.1.8 Installation

The ERYC GIS was supplied to the Public Protection Department of the East Riding of Yorkshire Council on a CD-ROM. A BGS officer installed and demonstrated the GIS to ERYC staff to ensure that it was working correctly, and to check that the staff could perform the basic operations. The ERYC staff involved felt that the exercise had been very worthwhile and found the GIS very user-friendly.

6.1.9 Concluding comments

The aim of this case study was to initiate a preliminary GIS for the East Riding of Yorkshire Council. Several datasets were loaded into the ERYC GIS, to which others will be added to in the future. The study has shown that setting up a basic GIS from scratch is achievable in a relatively short time (a few weeks). However, the process was aided by reasonably easy access to the necessary data sources and to personnel with advanced knowledge of GIS packages. Constructing a land quality GIS for a stakeholder new to GIS applications is a two-way process, in which training forms an essential part in order to help build confidence and to enable the GIS to be taken forward after handover.

ERYC staff have had the GIS for some six months now and have developed it immensely. The GIS now incorporates some forty extra layers than those added since BGS handed the project back to them. Such layers include allotments, brownfield sites, landfills, schools and groundwater source protection zones. The project has demonstrated that a Local Authority with limited experience of using GIS can develop an extensive GIS for the purpose of assisting in the decision making process relevant to the new contaminated land regime within a time period of approximately six months. The GIS has already been used to produce reports for internal ERYC enquiries on potentially contaminated land. ERYC staff hope to develop the system further to be able to produce reports for outside consultants and developers.

6.2 GIS for Leicester City

6.2.1 Introduction

Section 6.2 describes the process of constructing an Urban Contaminated Land GIS for Leicester City Council (LCCLGIS). The objective was to build a preliminary MapInfo GIS module for the city area compatible with the Leicester City Council's current IT strategy and the GeoEnviron[2] environmental information management system already in use by the Environment and Development Department. The GeoEnviron database is dedicated to contain and process data concerning past and present industrial activities of potential risk to the environment. It consists of a large number of related tables of environmental and administration information tied to the locations of interest.

6.2.2 Guide to the design and implementation of the LCCLGIS

The issues that were addressed during the process of implementing the LCCLGIS are:

1. Defining the problem (objective setting and planning)
2. Design of the GIS
3. Collation of existing digital datasets
4. Conversion of existing digital data
5. Quality of digital data
6. Purchasing digital data
7. Aerial photographs and other raster datasets
8. Linking the GeoEnviron database to the GIS
9. Data capture of non-digital datasets
10. Copyrights
11. GIS construction
12. Map projections and co-ordinate systems
13. Colour symbols and fills
14. Controlling the layers
15. Setting display depths
16. Installation.

Each of these stages is discussed below.

[2] GeoEnviron consists of modules able to handle all types of environmental data that can be digitally stored and interrelated to each other.

Defining the problem (objective setting and planning)
Early meetings between BGS and staff from the Pollution Control section of the Environment & Development Department helped to establish the current status of digital data holdings and IT facilities (see below) and the data requirements for the GIS. Only subsets of the more time-consuming datasets were to be loaded into the GIS in order to demonstrate the techniques. Written instructions on the methodology used to complete the loading of the datasets were to be passed on to the Department's staff on installation.

Design of the GIS
The design of the GIS is a joint process between the developers of a system and its potential users. It consisted of:

- identification of the datasets that will make up the final system;
- the choice of which GIS package to use - MapInfo was chosen to be compatible with the Council's IT strategy.

Collation of existing digital datasets
By far the most time consuming part in any project of this nature is data capture. The amount of data already available in digital form will affect enormously the time it takes to construct a working GIS. In Leicester's case, much of the data was already in digital form, but unfortunately in a different format to that required, and therefore format conversion had to be undertaken.

The following available information from the Environment & Development Department was passed onto BGS and input as layers into the LCCLGIS:

- digital OS maps (supplied in ArcView format)
- landfill site data (supplied in ArcView format)
- land use as depicted on the local plan (supplied as paper copy)
- aerial photographs of the city taken in 1998, 1981 and earlier (supplied in JPEG format).

These were combined with geoscience information held by BGS and other data layers from the Environment Agency (see Table 6.3 below).

Conversion of existing digital data
Data arrived in a number of digital formats, and although this is a relatively quick method of populating a GIS, there can be problems with the data conversion. For example the Ordnance Survey Land-Line® data arrived in ArcInfo library files format, which needed to be converted into a MapInfo-compatible format before being incorporated into the LLCLGIS. These conversions were carried out using a MapInfo file conversion utility (Universal Translator) that allows import and export of popular mapping file formats including ArcView. This conversion utility is an extremely fast method of converting the dataset, but unfortunately some of the OS datasets contained graphical text layers which could not be converted using this method. These text layers were not included, therefore, in the LCCLGIS, and other more time-consuming methods will have to be implemented to utilise them.

Quality of digital data
The quality of digital data varied greatly. In some cases fully attributed datasets were obtainable, but in others only the graphical linework was available. This is an important point to examine when acquiring data from other organisations, and care should be taken to ensure that the quality of the data is known before it is purchased.

Another problem encountered was that although one of the datasets appeared to be in a suitable format, it had been incorrectly input into the system by less experienced GIS users. Much work was needed to convert this dataset into a form suitable for use in the LCCLGIS.

Purchasing digital data

The cost of purchasing data, especially digital data, can be larger and more time consuming than expected. For this project relatively few datasets had to be newly purchased. The water course dataset was purchased from the Institute of Hydrology and the Sites of Special Scientific Interest dataset was purchased from English Nature. One of the problems associated with purchasing small portions of larger datasets is that although the price for the area required may be quite small, often standard fee handling charges can treble the price of acquiring the data. Annual licence fees are also required for the use of some datasets, and this can make the prolonged use of the data quite expensive.

Aerial photographs and other raster datasets

A set of aerial photographs, held in JPEG format, was available for the whole of the Leicester City region. These raster images were geographically located within the LCCLGIS to appear in the correct location as a GIS layer. Figure 6.10 is a screen-saved image from the LCCLGIS showing the aerial layer with other layers for a small area of the City. The location process required the National Grid co-ordinates to be given for the four corners of each image. This process took about three minutes per image to complete by hand, but this could vary depending on the computer specification. As there were over three hundred such images, about two staff-days of time would have been needed to complete this coverage manually. In the case of the LCCLGIS, a small program was written by an experienced programmer to complete this process automatically, thus reducing the time required to a few minutes. This program had the added advantage of avoiding the manual mistakes that might have crept in if done by hand. The 1:50 000 OS maps were also loaded into the LCCLGIS in this manner. For larger areas, the advantages of using a program to specify the National Grid co-ordinates become more obvious.

Table 6.3 Datasets for the Leicester GIS

Dataset	Description
Solid Geology	Solid Geology from the BGS 1:50 000 dataset
Superficial Deposits	Superficial Deposits from the BGS 1:50 000 dataset
Artificial Deposits	Artificial Deposits from the BGS 1:50 000 dataset
All Boreholes	All Boreholes taken from the BGS borehole database
Water Courses	All watercourses and surface water features, taken from the Institute of Hydrology dataset.
Water Wells	Water Wells taken from the BGS Water Well database
Water Abstraction Sites	Sites of Water Abstraction, taken from the Environment Agency dataset
Groundwater Vulnerability	Classification of groundwater (aquifers), taken from the Environment Agency dataset
Sites of Special Scientific Interest	SSSI areas assigned as sites of special scientific interest, provided by English Nature
Leicester City boundary	Provided in ArcView format by LCC
Pre-1972 landfill sites	BGS dataset
Contaminated sites	GeoEnviron database
Digital OS Land-Line® maps	Roads, buildings, OS lines

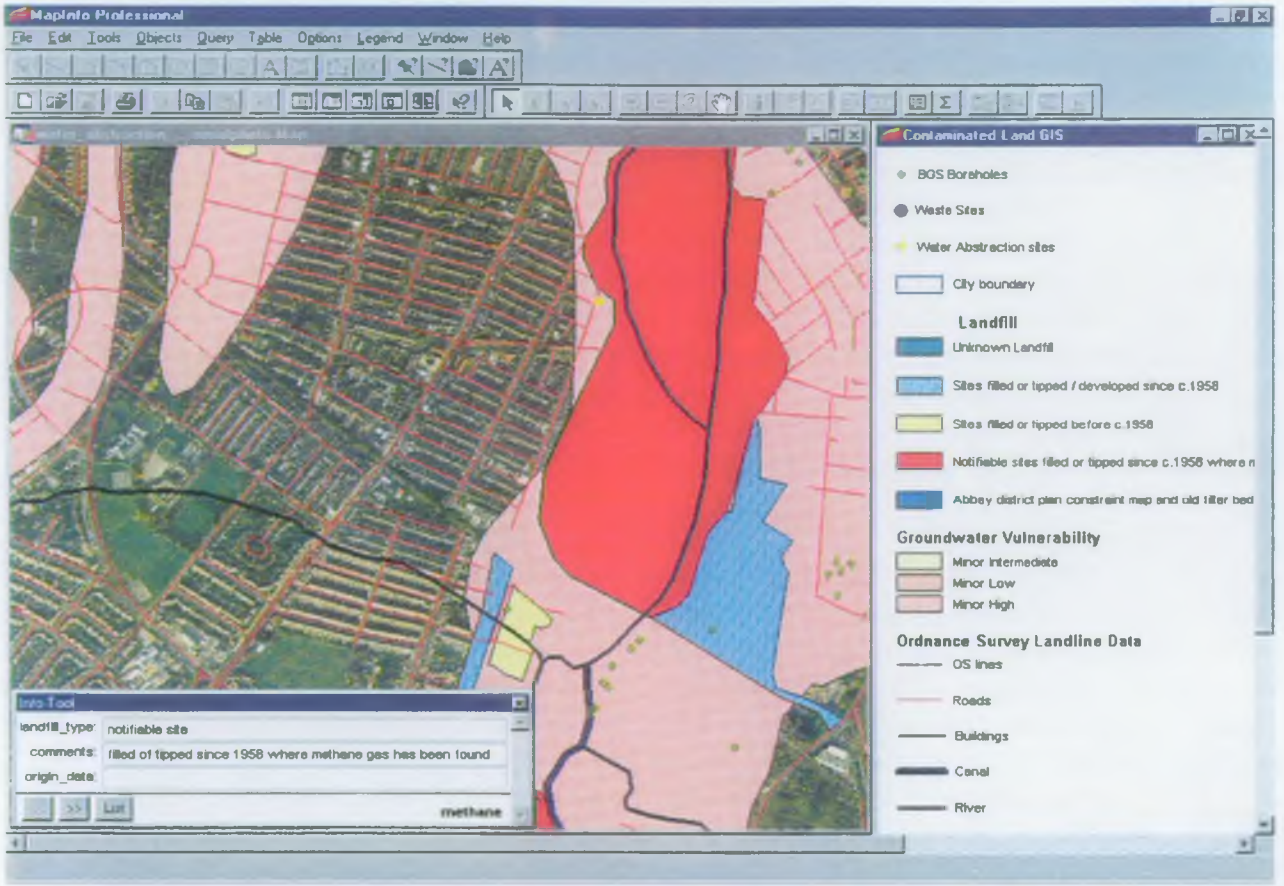

Figure 6.10. A screen download from the LCCLGIS showing the aerial layer with other layers for a small area of Leicester City. ©Crown Copyright. All rights reserved.

Linking the GeoEnviron database to the GIS

The Environment & Development Department of Leicester City Council were already using GeoEnviron, an environmental information management system written by a Danish company called Geokon. It was decided that a link between the GeoEnviron database and the LCCLGIS was required. Initially there were many problems with the integration of the two systems. After considerable consultation with Geokon, these problems were overcome, but the source of these problems was not fully identified. An important factor in making a link between the GIS and the database was to ensure that all the entries in the database had a geographical identifier, such as a National Grid location.

Data capture of non-digital datasets

As mentioned earlier, data capture is the most time-consuming part in the development of a GIS. In many cases, data may not exist in a digital format, and a substantial amount of time must be set aside for the labour intensive task of manually inputting, digitising or scanning of maps and other data. Obviously, this task requires the correct equipment to be in place. For example the historical land use information was only available in paper format and only a subset of the available paper maps was scanned and input into the LCCLGIS.

Once scanned, these images needed to be orientated to make them compatible with the British National Grid system. MapInfo does not have the ability to rotate or warp images, therefore the images had to be rotated in another package before they could be imported into the LCCLGIS. Corel Photo-Paint was used for this purpose. For each image the amount of

rotation required had to be calculated. Therefore, it is recommended that if many images are to be incorporated into a GIS, it may be less expensive to purchase a digital copy of the relevant County Series maps from e.g. Landmark, ensuring that the imagery purchased has been rotated to British National Grid.

Land use information could be incorporated into the GIS from other sources e.g. from an interpretation of the aerial photographic images.

Copyright issues

It is important that the copyright provisions of both digital and non-digital data are followed. The use of all the datasets listed in Table 6.3 require copyright licence agreements or some other formal acknowledgement of the dataset source. The Groundwater Vulnerability maps have jointly-owned copyright shared between the Environment Agency, BGS, the Soil Survey and Land Research Centre (SSLRC) and The Stationery Office. The nature of the agreements will depend on the intended use of the data.

GIS construction

There are a number of points that had to be taken into account during the construction of the GIS layers, these include map projections and visualisation. Both are discussed below.

Map projections and co-ordinate systems

Information in a GIS must be manipulated so that it registers, or fits, with information gathered from other sources. Projections are one part of the co-ordinate system of a map. Elements can have a co-ordinate system but no projection. A projection is used to reduce the amount of distortion that occurs when objects from a spherical surface are displayed on a flat surface. Different projections are used for different types of maps because each projection is particularly appropriate to certain uses e.g. a projection that accurately represents the shapes of the continents will distort their relative sizes.

The LCCLGIS is held in British National Grid format, but the data supplied in ArcView was held as Latitude and Longitude. This means that a simple conversion of the ArcView shapefile to a MapInfo.TAB file is not appropriate. Instead the file was converted into a MapInfo MIF/MID file. The header in the top of the MIF file had to be edited in a standard text editor to contain a British National Grid projection header (refer to the MapInfo manual for details). It is recommended that a new user refer to the MapInfo manuals before inputting any new datasets, even if the dataset is already in digital form.

Colour symbols and fills

Care was taken to ensure that the colours used in each layer were not confusing e.g. that water was coloured blue, and also that layers which need to be shown together were, where possible, coloured appropriately. The display can become confusing if multiple-filled layers are displayed simultaneously. Ideally, the colour symbols and fills should reflect published styles and colours.

Controlling the layers

Some of the raster datasets such as the aerial photographs needed extra manipulation. The number of files that were involved to enable a complete coverage of the entire city area was large, so switching these on and off was unrealistic. Therefore, a utility within MapInfo, called Seamless Table Manager, was used to link all datasets of the same type together in one seamless layer, thus enabling multiple files to be manipulated as one.

Setting display depths

Some of the datasets such as the raster images and the OS Land-Line® data are set within the GIS only to display below a specified scale. The reason for this is that above a certain scale the data become unreadable and very time-consuming to display (see Section 4.2 on scales).

Installation

The LCCLGIS was supplied to the Leicester City Pollution Control section in the Environment & Development Department on a CD-ROM, with instructions for connecting the GeoEnviron database to the GIS. As only subsets of the more time-consuming datasets were included in the GIS, written instructions on how to complete these datasets were passed to the Pollution Control staff.

Some feedback on the use of the LCCLGIS was obtained from the Pollution Control section three months after its installation. A development phase is underway to meet the following objectives:

- to validate the LCCLGIS database of potentially contaminated sites for Part IIA;
- to implement a report-writing function in order to identify what is present in the vicinity of sites of interest;
- to use the LCCLGIS as a general office tool for topics other than Part IIA matters;
- to plan its use as a corporate facility for other sections and departments.

The LCCLGIS is regarded as a vital instrument in the Leicester City strategy for managing contaminated land under the Part IIA regime.

6.3 GIS for the London Borough of Newham

6.3.1 Introduction

The Newham case study documents the design and development of a customised Contaminated Land GIS for a Local Authority who have significant previous experience of using GIS to answer contaminated land queries. A customised GIS differs greatly from a standard GIS implementation in that extra functionality is added to the system to answer specific queries which commonly need to be addressed by the users. Adding this extra functionality places more emphasis on the initial phases of the project, in particular the design of the system. It is important to identify the day-to-day tasks that can be automated by the GIS and to produce a design which will complete these tasks as effectively as possible. The development of a customised GIS requires constant interaction between the developers and users (in this case BGS staff and Newham staff) so that the final system correctly meets the needs of the users.

The work carried out under this Newham case study had the following objectives:

- conversion to an ArcView version
- the addition of a Word report writing facility
- the development of a risk assessment or prioritisation facility based on the 'development receptor' aspect outlined in the CLR 6 procedural document (DoE 1995).

6.3.2 Evolution of the Newham GIS project

In 1997 the Environmental Health Services Department of the London Borough of Newham commissioned BGS to develop a GIS of geoscience data relating to the Borough. The purpose of the GIS was to provide a foundation to aid future planning and decision making. After extensive discussions with staff at Newham, it was decided that:

- the GIS would be implemented in a leading GIS package, which was in use by Newham as their corporate GIS package;
- BGS would perform all data capture and collation and deliver to Newham a series of digital data layers in the GIS.

These layers would cover the broad topics of Land Use, Geology, Hydrogeology, Geochemistry and Site Surveys. The topics were used only as a means of data management within the accompanying written report as they were not differentiated within the GIS itself due to the limitations of the corporate package. Within each theme, the datasets are held as formatted layers, which are stored by the corporate GIS.

There then followed a period of about six months during which time the datasets were collated and entered into the corporate GIS. This development was performed at BGS using a copy of the corporate software kindly released to BGS for this purpose. Ordnance Survey Land-Line® data were included in the GIS under Newham's OS service level agreement.

On completion of all of the data layers (see Table 6.4 below), the GIS was installed at Newham and training was provided in its use. The product was then successfully used by staff at Newham to answer basic queries, produce site reports and generate site maps.

After using the GIS for some time, staff at Newham decided that they wanted to take the project further by customising the current GIS to produce standard reports and to provide some basic site risk assessment or prioritisation. These extra functions would then form the basis of their strategy for managing land contamination in the Borough. BGS were asked to investigate how this extra functionality could be implemented both using the corporate GIS and by using alternative software packages. It was concluded that the work could best be carried out by converting the datasets to ArcView. ArcView's development language Avenue could then be used to develop code which would provide the extra functionality required.

6.3.3 Extra functionality for report writing

The report writing facility allows the user to compile a report automatically in Microsoft Word from the datasets held in the GIS. This task takes three inputs from the GIS user:

1. A site to be searched. This site is digitised interactively by the user.
2. The datasets to be included in the report. The user is presented with a list of datasets included in the GIS. He/she is then able to select which datasets will be included in the report.
3. A search radius set by the user. Only features within this radius of the selected site will be included in the report.

A report is then generated, which includes:

- maps showing the selected site and the features from all the chosen datasets that fall within the site and the specified search radius;
- text description for each of the chosen datasets of all the features which lie within the site and the specified search radius.

An example of output from the Report Generator is given in Appendix 6.

Table 6.4 GIS Datasets for the Newham GIS

Dataset	Description
Solid Geology	Solid Geology taken from the BGS 1:10 000 dataset
Superficial Deposits	Superficial Deposits from the BGS 1:10 000 dataset
Artificial Deposits	Artificial Deposits from the BGS 1:10 000 dataset
All Boreholes	All boreholes taken from the BGS borehole database
Peat Boreholes	Subset of All Boreholes showing only those with information about peat (depth and thickness)
Gas Susceptibility Map	Estimated levels by BGS of surface methane risk (calculated from peat boreholes and overlying geology)
Soil Gas Data	Soil gas samples collected by BGS intended to validate the Gas Susceptibility Map
Pre-1900 Land Use	Digitised from Newham's paper maps
1920's Land Use	Digitised from Newham's paper maps
1960's Land Use	Digitised from Newham's paper maps
Unitary Development Plan	Digitised from Newham's paper maps
Site Investigation Reports	Digitised site boundary of contaminated sites, containing a summary of contamination information and a reference to further information
Landfills	Digitised site boundary of landfills, containing a summary of each landfill and a reference to further information
Water Courses	All water courses and surface water features, taken from the Institute of Hydrology dataset.
Water Wells	Water Wells taken from the BGS Water Well database
Water Abstraction Sites	Sites of Water Abstraction, taken from the Environment Agency dataset
Groundwater Vulnerability	Classification of groundwaters (aquifers), taken from the Environment Agency dataset
Geochemical Sample Sites	Sites chosen by BGS for geochemical samples (only covers a test area in the Borough)
Arsenic	Arsenic levels measured at Geochemical Sample Sites
Cadmium	Cadmium levels measured at Geochemical Sample Sites
Chromium	Chromium levels measured at Geochemical Sample Sites
Copper	Copper levels measured at Geochemical Sample Sites
Lead	Lead levels measured at Geochemical Sample Sites
Loss on Ignition	Loss on Ignition levels measured at Geochemical Sample Sites
Zinc	Zinc levels measured at Geochemical Sample Sites

6.3.4 Extra functionality for prioritisation

The risk assessment functionality allows contaminated sites to be prioritised based on whether a contaminated site is within a specified radius of critical land-use areas (e.g. housing and schools). It broadly follows the development prioritisation scheme outlined in DoE report CLR 6, and provides an illustration of how GIS can be used for prioritisation.

The result is a Microsoft Word report containing a classification of any existing contaminated site. This classification is in the form of an ordered ranking (A, B or C), which prioritises that site and allows potential remedial strategies to be assessed based on proposed end use.

An example of the output is given in the maps and associated text below.

Development Classification of Contaminated Site

Maps showing the selected site with both Landuse from the 1960s and the Unitary Development Plan. Buffers surrounding the site are shown at 50m (red) and 250m (blue).

1960s Landuse:
Number of residential areas within 50m of the site: 9
Number of open areas within 50m of the site: 0
Number of educational establishments within 50m of the site: 2
Number of commercial sites within 50m of the site: 2
Number of industrial sites within 50m of the site: 0
Number of residential areas within 250m of the site: 26
Number of open areas intersecting the site: 0
1960's Development Classification (CLR Report No. 6): A

Unitary Development Plan (UDP):
Number of residential areas within 50m of the site: 0
Number of environmental areas within 50m of the site: 0
Number of community service sites within 50m of the site: 1
Number of employment sites within 50m of the site: 0
Number of residential areas within 250m of the site: 0
Number of environmental areas intersecting the site: 0
UDP Development Classification (CLR Report No. 6): A

To extend the Newham example into a fully working prioritisation scheme would involve extending the system beyond development prioritisation to answer questions such as:

- what are the likely contaminants present?
- is a contaminated site within a specified radius of a water course?
- is the geology of a site such that contaminants will reach the underlying aquifer?

6.3.5 Feedback from Newham LA on the GIS project

Both systems, corporate and ArcView, are currently in place at Newham. This allows staff to carry on their daily tasks using the existing corporate system, whilst at the same time becoming familiar with the ArcView system. As this happens, dialogue between Newham staff and BGS staff will allow the ArcView system to evolve in a structured way.

Some feedback on the history and use of GIS was obtained from the Newham LA Pollution Unit:

"The nature of the London Borough of Newham as an historically industrial Borough with ongoing regeneration, is such that land contamination has been an issue for development control since the early 1980s. In 1996 the decision to amalgamate geochemical, geotechnical, hydrogeological, hydrological, geological and other data that exists for such parcels of land was made, and BGS was commissioned to present our data in a readily accessible format in line with our corporate GIS. Further to the addition of this data, other data pertaining to the natural environment in Newham was input into the system in conjunction with historical land-use data since pre-1900. We are currently aiming to have 1999/2000 land-use digitised by Spring 2000.

Prior to the corporate GIS, which has been running for over 1.5 years, our extensive data was held mainly in box files within Environmental Health and with Planning officers. Information for the natural environment was virtually unknown. The time spent on a query from a solicitor/resident or other bodies was 1-2 days for one officer, often involving looking through various box files and asking appropriate questions to other members of staff. The use of the GIS, also dependent on more staff resources being allocated to the Pollution Unit, has reduced this time to an average of 30-60 minutes for one officer, including the associated administrative functions.

Obviously the benefits of developing the GIS can outweigh the costs, although the initial costs were high for the data input, ongoing hardware costs and consultancy fees. The monies can be recuperated through an administration charge for information, which only applies to external bodies. The financial costs of the GIS development can never be fully redeemed, but the costs associated with officer time are outweighed by the benefits of having our data in an instantly retrievable format. This ensures that given adequate training, new members of staff can easily access the relevant data rather than rely on the knowledge of

longer-serving officers. We consider it to be an excellent management tool that has increased the overall efficiency and effectiveness of the Pollution Unit, in line with the principles of Best Value.

Further to the implementation of the Environmental Protection Act 1990 and on the advice of BGS, and due to the inherent problems with the corporate GIS in terms of analytical functions for our specific data, we have converted our data to run in ArcView. This will reduce one officer's time for one query to under 30 minutes, including administrative functions. Much of this reduction in time is due to work we have commissioned to BGS to have ArcView directly customised for our specific use with the appropriate Avenue programming. In terms of the Act, we are currently working on our prioritisation and categorisation procedure which will use specific Avenue programming in ArcView. Due to the extensive amount of data we hold and the large number of sites undergoing regeneration, it is our opinion that it would be impossible, without the use of GIS, to implement the requirements of the Act."

7 ACKNOWLEDGEMENTS

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APPENDIX 1 SOURCES OF CONTAMINATION

TABLE A.1 POTENTIAL CONTAMINANTS RELATED TO PAST INDUSTRIAL LAND USES AND PROCESSES

Industry	Contaminant	
	Type	**Example**
Gasworks	Coal tar	creosote
	Phenols	phenol
	Cyanides	free/complex
	Sulphur	sulphide/sulphate
	Metals	Ni/Cu/Pb/Co/Cr
Chemical works	Metals	As/Cu/Ni/Co/St/Ca/ Ba/Zn/Hg/Cr/Be/Pb
	Cyanides	free/complex
	Organics	PCBs, TCBs, solvents, hydrocarbons, pesticides, dioxins
	Other	Asbestos, paints, acids, alkalis
Mining	Mine wastes	Heavy metals, As
	Acid mine drainage	Fe, Mn, As, SO4
	Gases	Methane, CO2
Iron and steel works	Metals	Cu/Ni/Pb
	Acids	sulphuric, hydrochloric
	Mineral oils	-
	Coking works residues	(as for gasworks)
Metal finishing	Metals	Cu/Ni/Cr/Cd/Zn
	Acids	sulphuric, hydrochloric
	Plating salts	cyanide
	Aromatic hydrocarbons	benzene
	Chlorinated hydrocarbons	1,1,1-trichloroethane
Non-ferrous metal processing	Metals	Pb/Cd/Cu/Zn
	Impurity metals	antimony, arsenic
	Other wastes	battery cases, acids
Power stations	Metals	refractory materials, PFA
	Hydrocarbons	unburnt coal
	Organics	PCBs
	Other wastes	Asbestos
Oil refineries	Hydrocarbons	various fractions
	Acids, alkalis	sulphuric, caustic soda
	Lagging, insulation	asbestos
	Spent catalysts	Pb/Ni/Cr
Petrochemical plants	Acids, alkalis	sulphuric, caustic soda
	Metals	Cu/Cd/Hg
	Reactive monomers	styrene, acrylate, vinyl chloride
	Cyanide	toluene di-isocyanate
	Amines	aniline
	Aromatic hydrocarbons	benzene, toluene
Wood processing	Coal tar	creosote
	Chlorinated hydrocarbons	pentachlorophenol
	Metalloids/metals	As/Cu/Cr

Industry	Contaminant	
	Type	Example
Tanneries	Acids	hydrochloric
	Metals	trivalent chromium
	Salts	chlorides, sulphides
	Solvents	kerosene, white spirit
	Cyanide	methyl isocyanate
	Degreasers	trichloroethylene (TCE)
	Dyestuff residues	Cd, benzidine
Petrol stations	Metals	Pb/Zn/Cu/Ni/Cd
	Aromatic hydrocarbons	benzene
	Octane boosters	lead, MTBE
	Mineral oil	-
	Chlorinated hydrocarbons	TCE
	Paint, plastic residues	Pb/Cd/Ba
Textiles	Metals	Zn/Al/Ti/Sn
	Acids, alkalis	sulphuric, caustic soda
	Salts	sodium hypochlorite
	Chlorinated hydrocarbons	perchloroethylene
	Aromatic hydrocarbons	phenol
	Pesticides	dieldrin, aldrin, endrine
	Dyestuff residues	Cd, benzidine
Semi-conductors	Metals	Cu/Ni/Cd
	Metalloids	As/Zn/Sb
	Acids	nitric, hydrofluoric
	Chlorinated hydrocarbons	TCE
	Alcohols	methanol
	Aromatic hydrocarbons	xylene, toluene (BTEX)
Rubber processing	Metals	Zn/Pb
	Sulphur compounds	sulphur, thiocarbonate
	Reactive monomers	isoprene, isobutylene
	Acids	sulphuric, hydrochloric
	Aromatic hydrocarbons	BTEX compounds
Paints	Metals	Pb/Cd/Ba
	Alcohols	toluol, xylol
	Chlorinated hydrocarbons	methylene chloride
	Fillers, extenders	talc, silica, Ti. dioxide
Transport (garage workshops, railway depots, airports)	Hydrocarbons	various fractions, unburnt coal
	Lagging, insulation	asbestos
	Metals	Pb/Zn/Cu/Ni/Cd
	Degreasers	TCE, etc.
	Pesticides	E.g. Isoproturon, Mecoprop, Lindane etc.
Land restoration	Gases	methane, carbon dioxide, VOCs
	Metals	Cu/Zn/Pb
Docks, wharves & quays, canals	Metals	Fe/Pb/Zn/Cu/Ni/Cd etc
	Degreasers	TCE, etc.
	Hydrocarbons	various fractions, methane

Industry	Contaminant	
	Type	Example
Sewage treatment	Metals	Heavy metals in sludge
	Micro-organisms	Bacteria, pathogens, viruses
	Gases	Methane, carbon dioxide, H_2S
Intensive agriculture	Pesticides	E.g. Isoproturon, Mecoprop etc.
	Animal slurries	*Cryptosporidium* oocysts
	Fertilisers	Nitrate, phosphates

More information is detailed in the DoE Industry Profiles for different chemical, engineering, metal, cement, glass, timber, paper and sewage works; also for animal products processing works, waste and recycling plants and power stations. These are available from:

DETR Publication Sales Centre,
Unit 8,
Goldthorpe Industrial Estate,
Goldthorpe,
Rotherham S63 9BL.
Tel. 01709 891 318.

APPENDIX 2 SOURCES OF DATA AND INFORMATION

N.B. αindicates that digital data are available, and the numbers enable the reader to make easy reference to further details in Appendix 3.

LAND USE

	Initial data source (essential)	Where to find the data	Cost
1 α	OS maps Above in digital format	Ordnance Survey; local libraries. Local Authority/Ordnance Survey Land-Line® agreement	 Varies
2	Local Authority landfill and quarrying records	Local Authority Departments of Planning, Environmental Health	
2a α	Landfill site locations and records	The Environment Agency	No cost but see **Appx 5**

	Secondary data source	Where to find the data	Cost
3 α	Location of landfill sites in SiteFile Digests and SiteFile Database	Landmark Information Group Ltd.	Hard copy: £225 inc.VAT. Digital data £600 exc.VAT.
3a α	Landfill sites	Catalytic Data Ltd.	Prices on request
4 α	Register of landfill sites pre-1972	British Geological Survey	No cost
5α	Kelly's Trade Directories; Thomson Directories	Public and local libraries	
6 α	Digital images of old OS maps	Catalytic Data Ltd. Landmark Information Group Ltd. Scanning can be carried out by LAs under the Ordnance Survey Land-Line® agreement.	Landmark will scan a County Series ¼ sheet (equiv. to 4 plans at 1:2500) into a tiff file for £50+VAT
7	OS 1:1250 maps	Libraries; local authorities	
8 α	BGS 1:10 560 and 1:10 000 geological maps (published sheets and manuscript survey maps); hard copy. Digital data	British Geological Survey	 £75. £00s
9 α	National Land Use Database	DETR NLUD programme	Price on request
9a α α	Waste transfer, treatment and disposal sites; location of registered radioactive substances	The Environment Agency Catalytic Data Ltd.	No cost Prices on request

NATURAL CONTAMINATION

	Initial data source (essential)	Where to find the data	Cost
10	Radon potential maps (scale 1:625 000): hard copy with report	British Geological Survey	£71
10 a	Maps of Potentially Harmful Elements (scale 1:625 000): hard copy with report		£71
10 b	Maps of methane gas and oil seeps (scale 1:625 000): hard copy with report		£71

GEOCHEMISTRY SURVEYS OF WATER AND SOILS

	Initial data source (essential)	Where to find the data	Cost
11 α	Baseline geochemistry information (G-BASE): atlases; GIS-formatted data.	British Geological Survey	£50-£100 each; prices on request.
12 α	Wolfson Geochemical Atlas of England & Wales	Imperial College, London.	Data price on request
13 α	The Soil Geochemical Atlas of England and Wales; paper maps and GIS-formatted data	Soil Survey and Land Research Centre, Cranfield University.	Atlas out of print; but data prices on request

GEOLOGY

	Initial data source (essential)	Where to find the data	Cost
14 α	1:50 000 scale geological maps: hard copy; digital data.	British Geological Survey	£9.95; £00s.
14 a α	Borehole Records Database		Prices on request

	Secondary data source	Where to find the data	Cost
14 b α	BGS 1:10 000 scale geological maps; digital data	British Geological Survey	£00s (see prices in Appx 3)
15	1:10 560 scale geological maps		
16	DETR Applied Geological Maps	British Geological Survey; DETR and others.	c.£50 to £100

UNDERMINING AND NATURAL UNDERGROUND CAVITIES

	Initial data source (essential)	Where to find the data	Cost
17 α	MINGOL Minerals Database GIS viewed at 1:250 000 scale	British Geological Survey	On request
18 α	1:250 000 scale maps showing areas affected by undermining	Rust Environmental; DETR; (orginal reports in BGS Library)	£195 (per site report)
18 a α	1:250 000 scale maps showing areas affected by natural cavities		£195 (per site report)

	Secondary data source	Where to find the data	Cost
19 α	Detailed information on the extent of coal mining	The majority is held by the Coal Authority. Also BGS Coal Resource Map of Britain in GIS format. Records of some old mines are held by a variety of bodies (see list in **Appendix 4**)	varies
19 a	Information on other types of mining	See 17 & 18 above, and list in Appendix 4	varies

HYDROLOGY

	Initial data source (essential)	Where to find the data	Cost
20 α	1:50 000 OS map Landranger, folded or flat colour. 1:10 000 OS map flat outline. For digital maps see OS web site at:-	Ordnance Survey; local libraries and offices with OS agreements. http://www.ordsvy.gov.uk/	£5.25 paper. £18 paper. See Web site
21 α	Digital maps of drainage network (rivers, canals etc) at 1:50 000	The Institute of Hydrology	£16 per 100sq km for 1st year of licence
21 a α	River quality data	The Institute of Hyrology. The Environment Agency	On request. No cost

	Secondary data source	Where to find the data	Cost
22 α	Discharge consents data (under the Water Resources Act 1991); includes water quality	The Environment Agency	No cost

TOPOGRAPHY

	Initial data source (essential)	Where to find the data	Cost
23 α	OS maps: 1:10 000 raster and 1:50 000 raster digital terrain model (dtm) maps	Ordnance Survey. Libraries and offices with OS agreements.	£50-£70 per tile, includes copyright

	Secondary data source	Where to find the data	Cost
24 α	Slope steepness; derived from OS dtm	Ordnance Survey (e.g. Land-Form Profile maps at 1:10 000 at 5m contours)	£45-£200 per tile

HYDROGEOLOGY

	Initial data source (essential)	Where to find the data	Cost
25 α	Licensed water abstraction sites (analogue and digital data)	The Environment Agency. Institute of Hydrology	No cost. On request
26	Licence-exempt water sources e.g. domestic wells	Environmental Health Departments of local authorities.	
27 α	Water level data	British Geological Survey, Wallingford Office. Water companies	£7.50 per site.
28 α	Groundwater source protection zones (SPZs on 1:50 000 paper maps; polygons only on WWW)	The Environment Agency Regional Offices	No cost
29 α	Groundwater vulnerability maps	The Stationery Office supplies maps at 1:100 000 scale; hard copies (53); digital data on CD-ROM: 4 tiles; all 53 map tiles	Paper - £15 each; ~£250+VAT £3500+VAT
30 α	Flooding information (maps on CD-ROM)	The Environment Agency	No cost
30 a α	National River Flow Archive	Institute of Hydrology	Cost on request

	Secondary data source	Where to find the data	Cost
31 α	Information about aquifers - hydrogeological maps at 1:100 000 scale	British Geological Survey, Wallingford Office	£12.50 each
32 α	Information about floodplains - extent of alluvium shown on BGS 1:50 000 scale maps	British Geological Survey	On request
32 a α	Detailed information about deposits overlying aquifers on BGS maps and in memoirs		On request
33 α	Authorisations under the Groundwater Regulations and IPC	The Environment Agency	No cost
33 a α	Nitrate Vulnerable Zones - polygons in ArcView and MapInfo format 1:25 000	MAFF Regional Service Centres	On request (min.£25)
34 α	Detailed information about flood risk	OS digital terrain models at 1m resolution or better; historical records.	On request

CONSERVATION DATA

	Initial data source (essential)	Where to find the data	Cost
35 α	Location of Sites of Special Scientific Interest (SSSIs)	English Nature	National coverage: Digital data: £400 14 paper maps at 1:200 000 give national coverage: £16 each + P&P
35 aα	Location of National Nature Reserves (NNRs)		
35 bα	Location of Special Areas of Conservation (SACs)		
35 cα	Location of Ramsar Sites		
35 dα	Location of Special Protection Areas (SPAs)		
36 α	Areas of Outstanding National Beauty (AONBs) and National Parks	The Countryside Commission	On request
37 α	Location of scheduled ancient monuments	English Heritage	No cost
38	Location of Green Belts	Local authority plans	

	Secondary data source	Where to find the data	Cost
39 α	Baseline ecology and soil quality; types of landscape, land cover, ecosystem and soil	The Institute of Terrestrial Ecology	On request
40 α	Environmentally Sensitive Areas (MAFF designation)	MAFF; the Farming and Rural Conservation Agency	On request

APPENDIX 3 NOTES ON INFORMATION SOURCES

Addresses and Notes

The bold numbers listed below refer to the data sources listed in the Tables of Appendix 2.

Land Use

1 Ordnance Survey is Britain's National Mapping Agency. Land-Line® is the definitive large-scale dataset surveyed at 1:1250 scale in urban areas, 1:2500 in rural areas and 1:10 000 in moorland areas. It is regularly revised and updated (depending upon the changes occurring in an area), and is available in vector data format with full feature coding. However, the digital layer fit for most purposes of forming the backdrop for Local Authority databases of contaminated and potentially contaminated sites is the 1:10 000 raster map.

Information on all Ordnance Survey Products is available from:

Ordnance Survey
Romsey Road
Maybush
Southampton SO9 4DH.
Tel 02380 792773.
Web http://www.ordsvy.gov.uk/

The web site is particularly helpful in describing the full range of products and their prices.

2a The Environment Agency has responsibility for records on waste disposal sites that were formerly kept by the Waste Regulation Authority. The locations of registered sites are available in digital form and are updated every three months. Digital data for some of the Environment Agency Regions are available as GIS-formatted polygons. The Environment Agency address for landfill data is:

National Centre for Environmental Data and Surveillance
The Environment Agency
River House
Lower Bristol Road
Twerton
Bath BA2 9ES.
Tel 01278 457 333.
Fax 01225 469 939.
Web http://www.environment-agency.gov.uk/

Appendix 5 gives a guide on the costs, if any, that may be incurred when requesting Environment Agency datasets. Once revised, a new Catalogue of Data Sources will be available on a CD-ROM which will hold all the details of the Environment Agency

datasets, including plots of sampling points.

3 A directory of waste disposal and treatment sites, 'The Sitefile Digest', was formerly compiled by Aspinwall & Co from publicly available information such as the registers of licences held by the Environment Agency. However, now these SiteFile reports are produced by Landmark who maintain and sell the SiteFile Database:

Landmark Information Group Ltd
7 Abbey Court
Eagle Way
Sowton Industrial Estate
Exeter EX2 7HY
Tel 01392 441728
Fax 01392 441709.
Web http://www.landmark-information.co.uk/

In addition to the comprehensive listing of waste disposal sites by county, it contains a useful introduction to the licensing of waste management, duty of care, legal liabilities and practical considerations. The information appearing in the Digest is a condensation of that held on a computer database which can be searched for sites by category, such as geographical area, site type and waste type.

3a The Environment Agency has recently supplied data for a new CD-ROM, Sitescope Environmental, published by Catalytic Data Ltd. The CD-ROM contains a range of Environment Agency information including abstraction and discharge consents, landfills, pollution incidents, groundwater vulnerability, water quality, radioactive substance consents and integrated pollution control authorisations. The CD-ROM also has information from a variety of other organisations including the British Geological Survey (solid geology, landslip and boreholes); DETR (hazardous substance consents); English Nature (SSSIs and other sites); the Countryside Commission (National Parks and Areas of Outstanding Natural Beauty); the National Radiological Protection Board (radon risk); and the Valuation Office (current industrial use). The contact address is:

Catalytic Data Ltd.
PO Box 606
Bromley
Kent BR1 2ZR.
Tel 0870 606 1700
Fax 0870 606 1703
E-Mail info@sitescope.co.uk
Web http://www.sitescope.co.uk

4 Register of Landfill Sites (pre-1972)

During 1972 to 1974, a national survey of landfill sites was performed by BGS on behalf of the Department of the Environment. Data recorded for each site included a brief history of the site, site map, local geology, types of waste disposed of and a brief risk assessment of the sites potential to pollute surface and/or groundwater resources.

A summary of data is held digitally on the British Geological Survey's Geoscience Data Index (GDI) geo-referenced with British National Grid coordinates. More extensive paper records are available for each site on request. The GDI can be accessed at:

British Geological Survey
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3241
Fax: 0115 936 3488.
Web http://www.bgs.ac.uk/

British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
Tel: 0131 667 1000
Fax: 0131 668 2683

British Geological Survey
London Information Office
Natural History Museum Earth Galleries
Exhibition Road
London SW7 2DE
Tel: 0207 589 4090
Fax: 0207 584 8270.

5 Kelly's Trade Directories have been published annually since 1798. Many libraries hold reference copies. They include information about businesses and their addresses. Information about Kelly's can be obtained from:

Kelly's Directories
Windsor Court
East Grinstead
West Sussex
RH19 1XB
Tel 01342 326972.
Web http://www.kellys.co.uk/

Thomson Directories sells a Business Search UK CD-ROM with over 2.1 million UK business addresses. It is obtainable from:

Business Information Department
Thomson Directories Ltd.
Thomson House
296 Farnborough Road
Farnborough
Hants. GU14 7NU.
Tel 01252 390562 or 0645 63 6261

Fax 01252 371720
E-mail: bsp@thomweb.co.uk

6 Landmark Information Group have scanned images of old Ordnance Survey large-scale maps. (See **3** and the Web site.)

7 see **1**

8 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. The larger scale maps show the location of mineral workings and mines; more recent maps show also the distribution of man-made deposits.
The maps are available for purchase direct from BGS outlets as detailed below:

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

British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
Tel: 0131 667 1000
Fax: 0131 668 2683

British Geological Survey
London Information Office
Natural History Museum Earth Galleries
Exhibition Road
London SW7 2DE
Tel: 0207 589 4090
Fax: 0207 584 8270.

Increasingly, the map products are being made available in digital form under licensing agreements. The digital map information is structured so that thematic information can be automatically generated and used in GIS. Information about digital availability, format and charges can be obtained from the Cartographic Data Manager, BGS Keyworth. (See also **14** and **14b** below.)

9 The **National Land Use Database (NLUD) Survey** is being developed in partnership between the DETR, Ordnance Survey, English Partnerships and the Improvement and Development Agency. The URL web address is http://www.nlud.org.uk/. The first

phase will involve local authorities in England providing information on previously developed land or brownfield sites, which are available for development. NLUD has a polygon capture strategy for site boundaries, and it describes the software tools for the capture and output of polygon data at http://www.lgmb.gov.uk/nlud. There is a NLUD Help Desk on tel. 0207 890 5508. Future NLUD phases will extend the database to all uses of land and maintain it as a national resource.

Feeding off the NLUD Survey is the **National Brownfield Sites Project**. This ends in May 2000 and has a remit to classify different types of brownfield site and to consider the location and spatial distribution of the different categories. The National Brownfield Sites Project is run by:

Urban Mines Ltd.
PO Box 89
Parry Lane
Bradford
West Yorkshire
BD4 8TW
Tel. 01274 755 793 / 799
Fax 01274 755 040.
E-mail urbanmines.brownfield@dial.pipex.com
Web http://urbanmines.org.uk/urbanmines/

9a The Environment Agency can supply national digital data; for the address see **2a**. Data are also available from Catalytic Data Ltd (see **3a** above for address).

Natural Contamination

10, 10a & 10b see **8**

Natural Contamination Review of Great Britain

This study (Appleton, 1995) reviewed the relevance to planning and development of natural contaminants from geological sources throughout Great Britain. The review was based on literature and data from readily accessible library and archive sources. It presents a map at a scale of 1:625:000 highlighting areas of above average national background concentrations of a range of potentially harmful elements (PHEs), including As, Cd, Cu, Pb and Zn. The National Soil Inventory datasets for England, Wales and Scotland were of insufficient resolution to define natural contamination for planning purposes. For this reason, the map was generated using the stream sediment geochemical datasets of the Wolfson Geochemical Atlas of England and Wales (Webb et al., 1973) and Geochemical Baseline Survey of the Environment (G-BASE) programme of the British Geological Survey (see **11** below).

A statistical procedure, involving the interpretation of cumulative frequency curves, was used to distinguish natural background concentrations in stream sediments from higher concentrations derived from weathering in areas of metalliferous mineralisation or mine spoil. Although the range of natural background concentrations varies in different geological settings, a NAB (national average background) concentration was derived for each of the PHEs. For each PHE, the

stream sediment data were subsequently classified into those below NAB, between NAB and 2 x NAB, 2 to 4 x NAB and greater than 4 times NAB. An interpolation procedure was used to grid the data. The five element datasets were superimposed and the highest value selected for each grid square. Data presented in the map are of variable resolution based on the stream sediment sampling density (1 sample per 1.6 to 2.5 sq km).

The map indicates that relatively large areas of the land surface of England are characterised by above NAB concentrations of the five PHEs. This is most notable in parts of the Lake District which exhibited above national average background concentrations of As, Cd, Pb, and Zn due to secondary enrichment. The most extensive areas with the highest values of above national background values occur throughout the Pennines and southwest England. These values can be attributed to areas of former metalliferous mining.

On the basis of a comparison between stream-sediment and soil data, it was concluded that areas with greater than four times the background concentration of PHEs in stream sediment are likely to contain soil concentrations that require further investigation. This conclusion was derived on the basis of the ICRCL guideline values which applied at that time.

Other maps were generated to show the distributions of natural methane, carbon dioxide and oil seeps (Appleton and others, 1995).

Information on radon potential maps is also available from BGS. These maps indicate the susceptibility of the ground to radon emission.

Contact details: Analytical and Regional Geochemistry Group,
British Geological Survey, Keyworth. Tel: 0115 9363100. Fax: 0115 9363200.

Geochemistry Surveys of Water and Soils

11 see **8**

BGS Geochemical Baseline Survey of the Environment (G-BASE)

The G-BASE programme began in 1968 and is currently surveying the whole of the UK from north to south. The survey is scheduled for completion by 2012. The survey is based on the collection and analysis of stream sediments at a density of 1 sample per 1.5 sq km and surface waters at an average density of 1 per 3 sq km. 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 are available for much of Northern Britain and Wales for 35 inorganic elements. Water quality parameters are determined in surface waters in addition to an extensive range of major and trace elements.

As developments have been made in analytical techniques, it has become possible to

carry out simultaneous analyses for an increasing suite of parameters and a wider range of sample media. Recent publications therefore contain a wider range of elements for sediment, soil and water, with determinations made to lower detection limits than were possible in the early stages of the programme.

The data are presented in the form of Geochemical Atlases, which describe sampling and analytical methodologies, and present element distribution maps accompanied by interpretative text. Atlases currently published cover the Lake District, Northeast England and Northwest England. Atlases covering the Welsh Borders and the West Midlands are scheduled for publication in 2000. It is expected that data will be released for the Humber Trent region in 1999. Sampling of the East Midlands is ongoing. The data for England are part of a continuous dataset, which also encompasses Wales, Scotland and Northern Ireland. Recently, several urban areas have also been surveyed (at 4 samples per sq km), mainly in South Wales and the Midlands. In addition to the atlases, all data are available digitally, and representative splits of all solid sample media are archived at the BGS in the National Geosciences Data Centre (NGDC).

During its initial phases, the programme concentrated on the collection of stream sediment and stream water samples from first and second order streams in rural areas. As the programme moved into lowland areas of the country, where the drainage network was less well developed, rural *soil* samples were also collected. The stream sediment and rural soil data provide valuable information on the background concentrations of inorganic contaminants in the surface environment. These datasets also include information on naturally elevated levels of contaminants associated with certain rock types, and elevated concentrations of contaminants occurring naturally but enhanced by anthropogenic activities such as mining. The surveys may indicate anomalies caused by former land use activity hitherto undocumented.

Data are available through the G-BASE data officer (see below) at BGS, Keyworth, either as paper maps or in digital form. Raw data are held in an Oracle database and are spatially referenced using GB national grid coordinates (Ordnance Survey). Data are also available in a number of GIS formats (including MapInfo and ArcView). The cost of the information can be discussed on an individual area basis.

Individual atlases are sold through the Sales Desk, British Geological Survey, Keyworth, Nottingham, NG4 5GG (Tel: 0115 9363241; Fax: 0115 9363488), at a cost of between £50 and £100 depending upon region.

For information on national, regional and local **surveys of organic compounds** in soils and water, the reader is referred to the series of R&D Technical Reports produced by the Environment Agency's National Groundwater and Contaminated Land Centre under its R&D Project P5-019 entitled 'Information on Land Quality in the UK'. See **25** for the Centre's address.

12

The Wolfson Geochemical Atlas of England and Wales

This atlas provides an overview of the chemical composition of the geological and surface environment throughout the whole of England as part of a continuous dataset, which also covers Wales. Data was based on the collection of stream sediment samples at the junctions of small streams (those with an upstream catchment of less than 25 sq km) with roads. This provided data points at an average density of 1 per 2.5 sq km. A range of trace elements were analyzed by a spectrographic technique on a direct reading ARL 29000B Quantometer. Zn, Cd, Mo and As cannot be adequately determined spectrographically and were thus analyzed by different techniques. Zn and Cd were analyzed by Atomic Absorption Spectroscopy (AAS) following a nitric acid digestion. Solutions of As and Mo, produced after fusion with potassium hydrogen sulphide, were analyzed by established methods: As by the Gutzeit method (colorimetry after formation of arsine) and Mo by spectrophotometry after formation of the toluene dithiol complex and extraction into toluene. Sets of computer generated maps are shown for Al, As, Ba, Ca, Cr, Co, Cu, Ga, Fe, Pb, Li, Mn, Mo, Ni, K, Sc, Sr, V and Zn displaying the data in percentile classes and in empirical class divisions.

Quality control was carried out to monitor systematically the precision and accuracy of analytical and numerical data. However, re-analysis was only undertaken where errors would cause significant deviations in the overall geochemical distribution of a given parameter. This methodology was compatible with the aim of the study, which was to delineate broad scale geochemical patterns, rather than to provide point source information.

Contact: Prof. Ian Thornton, T.H.Huxley School of Environment, Earth Sciences and Engineering, Imperial College, RSM Building, Prince Consort Road, London SW7 2BP. Tel: 0207 594 6390. Fax: 0207 594 6403. Email: i.thornton@ic.ac.uk.
Web: http://www.huxley.ic.ac.uk/RGROUPlist.html.

13

The Soil Geochemical Atlas of (England and Wales)

This atlas presents and interprets soil maps of England and Wales (from the National Soil Inventory, 1978-1982) for pH, organic carbon, total (acid extractable) and extractable concentrations of major elements, nutrients and some trace metals in top-soil samples at a resolution of 1 sample per 25 sq km. Samples were collected in non-urban areas. Following sieving to 2mm, "total" concentrations were determined by ICP-AES (inductively coupled plasma atomic emission spectrometry) after an *aqua regia* digestion in nitric and hydrochloric acid. Extractable concentrations were determined by a range of standard procedures i.e. (P, 0.5 M sodium bicarbonate; K and Mg, 1.0 M ammonium nitrate; remaining trace elements, 0.05 M EDTA pH 7.0). Organic carbon contents were determined by loss on ignition or dichromate digestion, while pH measurements were obtained by shaking 10 ml of soil for 15 minutes with 25 ml of distilled water and inserting a pH electrode into the solution. Quality control procedures included: the incorporation and analysis of control samples; the use of reference soils and blank digests (to check for contamination); repeat analyses and sample randomisation.

This atlas provides a broad scale picture of variations in top-soil geochemistry at the

national scale. Maps and summary statistics are shown for the distributions of soil pH, organic carbon, total and extractable concentrations of Al, Ba, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, P, K, Na, Sr and Zn. Interpretations are made of the distributions in relation to soil type, geology (and mineralogy), fertiliser applications and mining contamination. Comparisons are made between the distributions of total and extractable concentrations. Localised increases in metal concentrations are attributed to mining and smelting, and the application of sewage sludge.

Of particular general relevance to land quality and the mobility of pollutants are the maps of soil pH, organic matter content, and to a lesser extent phosphorous. These maps give an indication of the likely variation in the natural attenuation of potentially harmful elements.

Data are available digitally and in hard copy (maps etc). It is spatially referenced using national grid coordinates (Ordnance Survey) and additionally may be made available in a number of GIS formats.

Contact: Dr P. Loveland, Soil Survey and Land Research Centre, Cranfield University, Schools of Agriculture, Food and Environment, Silsoe, Bedford, MK45 4DT. Tel: 01525 863242; Fax: 01525 863253; e-mail: soil.survey@cranfield.ac.uk; Web http://www.cranfield.ac.uk/sslrc/

Geology

14 see **8.**

The digital 1:50 000 geological maps from BGS cost the following:

Map unit	Vector linework or raster		Attributed vector	
	Year 1	Yr 2 onwards	Year 1	Yr 2 onwards
20x28 km	£175	£45	£265	£65

14a see **8**

BGS Borehole Records Database

The British Geological Survey holds records of site investigations, waste sites, borehole records and mine plans from over 160 years of surveying and research. In addition to borehole records from investigations undertaken by BGS, a range of commercial organisations, including oil and construction companies, also donate records and reference material.

Information on the borehole records database is available from: Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG. Tel: 0115 936 3241; fax: 0115 936 3488.

14b see **8**

The digital 1:10 000 geological maps from BGS cost the following:

Map unit	Vector linework or raster		Attributed vector	
	Year 1	Yr 2 onwards	Year 1	Yr 2 onwards
5 x 5 km	£120	£30	£180	£45

It is also worth noting that the BGS has digitised the 3-D geology of the Greater London area within a MapInfo GIS called LOCUS. The area is roughly bounded by the M25 orbital ring road. LOCUS allows synthetic borehole logs to be generated at any point down to the top of the Chalk, and cross-sections can be very quickly generated along any chosen series of lines. Groundwater levels are also held in LOCUS.

15 see **8** 1:10 560 coverage is available from the BGS Sales Desk at Keyworth.

16

Since the early 1980s, the former Department of the Environment had commissioned 57 applied geological mapping (AGM) research studies of selected areas of Great Britain; 35 were in England and Wales. 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, resources and development constraints. 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 in England and Wales covered by applied geological maps are described in Smith and Ellison (1999), and are as follows:

Aldridge-Brownhills
Black Country
Bournemouth-Poole
Bradford
Bridgend
Brierley
Bristol
Chacewater
Coventry
Cramlington-Killingworth
Crosby-Bootle-Aintree (Sefton)
Deeside
Dearham & Gilcrux, West Cumbria
Exeter
Fareham & Havant
Garforth-Castleford-Pontefract
Great Broughton & Lamplugh
Leeds
Morpeth-Bedlington-Ashington
Newcastle

Nottingham
Ponteland-Morpeth
Plymouth
Severn Levels
South-west Essex
South-east Leeds
Southampton
South Humberside
St Helens
Stoke on Trent
Torbay
West Wiltshire & South-east Avon
Wigan
Workington & Maryport, West Cumbria
Wrexham.

Those study areas listed above which are highlighted in bold type have digital databases of information associated with them. The urban area of Wolverhampton has also been investigated (see Bridge and others 1997). This study was carried out by BGS specifically to place the information into a MapInfo GIS called WOLGIS.

The output from many of the listed AGM 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
Darking Road
Leatherhead KT22 8JB

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

Further information on the availability of these studies can be obtained from:
Department of the Environment, Transport and the Regions
Minerals & Waste Planning Division
Zone 4/A2
Eland House
Bressenden Place
London SW1E 5DU.

Undermining and Natural Underground Cavities

17 see **8**

BGS MINGOL Minerals Database

MINGOL is a GIS containing the nature and distribution of British metallic, industrial and construction mineral deposits, in the context of current planning and environmental constraints. It forms an easily accessible minerals information system, based on the capture and integration of BGS mineral resource datasets, from which value-added products can be developed to meet customer needs.

The datasets include information on 2500 active mines and quarries, several thousand metalliferous mineral occurrences and metalliferous mineral exploration areas. There is also an increasing amount of mineral resource and mineral planning consent information as the on-going DETR Mineral Resource Planning Map series is converted to GIS format. The datasets are viewed using the national 1:250 000 OS Strategic topography. A range of planning constraint data is also available, including areas of National Parks, Areas of Outstanding Natural Beauty (AONBs), SSSIs, Heritage Coasts and Scheduled Monuments in England and Wales. Much of this constraint data is obtained from other organisations (and in some cases from licensed third party suppliers of digital data).

The individual datasets are all in the process of development and gathering of additional data. There is national coverage of active mines and quarries and

metalliferous mineral exploration. Mineral occurrence data is mainly complete for northern England and Wales, with limited data for Scotland. The DETR Mineral Resource Planning Map series is currently only available for a limited number of counties, but will eventually cover England and Wales. Additional functionality is under development, including Internet developments to allow access or even download of selected information. The datasets are combined within an ArcView GIS system. The MINGOL system is on-going with data collection and verification. Digital and paper outputs are available on request, and can be tailored to suit client needs.

Contact: British Geological Survey, Keyworth, Nottingham.
Tel: 0115 9363241 Fax: 01487 773488. Web: http://www.bgs.ac.uk

18 A series of nation-wide review projects covering ground-related issues were commissioned by the Department of the Environment between 1986 and 1995. One on mining instability was carried out by Arup Geotechnics and published in 1992. Reference: Arup Geotechnics, 1992. Review of Mining Instability in Great Britain, Summary Report. London: HMSO.

The outputs from the project are:

- Summary report , three volumes of technical reports and two 1:625 000 summary maps
- Volume 1: contains 10 Geographical Reviews in the form of Regional reports with associated maps at 1:250 000 scale of counties with Ordnance Survey topographical base and plastic overlays with mining information.
- Volume 2 i: The Effects of Mines,
- Volume 2 ii: Investigation Methods for Disused Mines,
- Volume 2 iii Mining Subsidence Preventive and Remedial Measures
- Volume 2 iv: Mining Subsidence Monitoring Methods
- Volume 2 v: Procedures for Locating Disused Mine Entries.

Each regional report is allocated a series of mining area codes. Within them are mining area schedules each of which consists of data sheets with information including the mineral or minerals worked, method and dates of working, geology, drainage and incidences of subsidence.

Information is divided into mineral types, namely metalliferous, including associated vein minerals (e.g. copper and barite), rock (e.g. sandstone), coal and associated minerals, iron (not including coalfields) and evaporites (e.g. salt, gypsum).

Areas where mining is known or suspected are depicted on the 1:250 000 scale maps in 1km square pixels. Each area of mining is colour coded by mineral type and cross referenced to a mining area code and a data sheet.

18a A further report commissioned by the DETR concerned the distribution of natural cavities in Great Britain. The reference is: Applied Geology Limited. 1994. A review of instability due to natural underground cavities in Great Britain, 2 Volumes.

The outputs from the project are:

- Summary Report
- Volume 1: regional reports in 10 volumes with associated regional maps at 1:250 000 scale which are plastic overlays with a national grid for referencing against Ordnance survey topographical base.
- Volume 2: technical reports dealing with the nature and occurrence of natural cavities and their significance for planning and development (Vol. 2.1), a review of site investigation techniques (Vol. 2.2), and a review of ground treatment methods (Vol. 2.3).

Vol. 1.2 of this report contains map overlays showing locations where natural cavities are recorded and there is supporting information and guidance notes to assist planners. On the maps each cavity type has a different symbol and the details about each locality are held in a separate database. This database has been combined with the national data on man-made cavities collated during the DoE-funded review of mining instability. It is not exhaustive, but is considered to be representative.

The digital database is now maintained by Rust Environmental who provide site reports (cost £195) which include detailed information from the mining instability and natural cavities databases.

Rust Environmental
Cranford
Kenilworth Road
Blackdown
Leamington Spa CV32 6RG.

Information about the availability of these reports can be obtained from the DETR (see **16**).

19 & 19a

The principal source of detailed information on coal mining is the Coal Authority. Many smaller databases of private coal mines and other types of mines, including salt, gypsum and metalliferous mines reside in a variety of locations (see **18**). BGS has produced a report on **Sources for Mining Data in Great Britain** and a copy is appended (Appendix 4).

The British Geological Survey has a digital 1:1 500 000 Coal Resource Map of Britain showing areas of exposed and concealed Coal Measures with contours of the base boundaries of the beds. Inset maps at 1:400 000 show contours of the top boundaries. This digital information is placed within the BGS MINGOL system (see **17**).

Hydrology

20 see **1**

21 The Institute of Hydrology provide digital data on water courses ('blue line' data) based on Ordnance Survey 1:50 000 topographical maps. For an organisation with no OS agreement, the costs are £16 (excluding VAT) per 100 sq km for the first year of the licence for digital lines, £11.20 for the second and subsequent years. For bodies with OS agreements, the prices are lower. There may also be a handling charge to pay.

Institute of Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB.
Tel 01491 838800
Fax 01491 825338.
Web http://www.nerc-wallingford.ac.uk/ih/

21a The Institute of Hydrology (see **21** above) publishes a river water General Quality Assessment (GQA), classified A to F in terms of chemical and biological quality. Assessments are made on 'blue line' watercourses as under **21.** The Environment Agency holds river quality data too - see **2a**.

22 The Environment Agency regulates the consents for discharges to watercourses - see **2a**. Databases of water quality information from monitoring are available for some reaches.

Topography

23 see **1**

24 see **1**

Information on slopes can be obtained from contour information provided by the Ordnance Survey. See the OS Web site. The information is available in digital form and, when processed using appropriate software, areas with similar slope angle can be determined.

Hydrogeology

25 Data on water abstraction can be obtained from the Environment Agency (see also **2a**) and the Institute of Hydrology (see **21**). The main Environment Agency Centre for groundwater matters is:

National Groundwater and Contaminated Land Centre
The Environment Agency
Olton Court
Warwick Road
Olton

Solihull
West Midlands B92 7HX.
Tel 0121 711 5885
Fax 0121 711 5925.
E-mail: ngwclc@environment-agency.gov.uk
Web: http://www.environment-agency.gov.uk/gwcl/index.htm

26 Each local authority environmental health department keeps the licence-exempt well records for its local authority area.

27 Information on groundwater levels measured weekly and monthly in selected boreholes is available from:

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

The Water Well Archive Database has 100 000 paper records of water wells, including details of water levels, yields, lithologies and water chemistry.

See also the Institute of Hydrology Web site, http://www.nerc-wallingford.ac.uk/ih/, for more information on the National Water Archive and the National Groundwater Level Archive. The Environment Agency Regional Offices also hold water level data.

The BGS LOCUS GIS contains a water level dataset for the greater London area. (The LOCUS GIS arose from the BGS 'London Computerised Underground & Surface Geological Project'. It covers the greater London area, roughly marked by the M25 orbital motorway. Its main layers are topography, made ground, drift geology, solid geology and borehole data. It is useful for generating synthetic sections, digital maps and 3-D perspectives.)

28 Aquifer protection is the responsibility of the Environment Agency (see **25**). Groundwater Source Protection maps are produced by the Environment Agency as part of its risk-based framework for evaluating development proposals that may impact on underlying groundwater resources. The maps at 1:50 000 scale designate source protection zones (SPZs) for around 2000 public supply abstractions. The printed maps show the protection zones, the groundwater vulnerability classification (see **29**) and the OS base map. Three zones are defined around each particular abstraction borehole based on travel times of the groundwater (Zone 1 =50 days; Zone II = 400 days) and the total catchment area of the abstraction (Zone III). These Zones are digitised. A strategy of maintenance and update of the Groundwater Source Protection maps is being implemented by the Environment Agency's National Groundwater and Contaminated Land Centre. GIS-based products are planned to

enhance operational capability. Data will be available for download free-of charge from the Environment Agency's Web site.

Information is available through the Environment Agency's regional offices. For the addresses of these regional or area offices see the Web site at http://www.environment-agency.gov.uk/

29 The Environment Agency has produced a series of 53 Groundwater Vulnerability maps to cover England and Wales at a scale of 1:100 000. The maps are published and supplied by The Stationery Office at:

The Stationery Office Ltd.
PO Box 276
London SW8 5DT.
Tel 0870 6005522
Fax 0870 6005533.

The maps are designed so that planners, developers and consultants can identify the vulnerability of groundwater to contamination from a limited group of chemicals such as nitrate. The maps will help to ensure that developments conform to Environment Agency 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. 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. Each Groundwater Vulnerability map is available in three digital formats on a single diskette. The files contain the vector linework, which defines the various vulnerability classes. More work is planned to address contaminant-specific vulnerabilities.

The contributors and holders of the original information and source data for these maps are:

British Geological Survey (see **8**)

and

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

30 The Environment Agency has the responsibility for assessing areas prone to tidal and river flooding. Maps (known as Section 24 maps) that illustrate flood risk are, generally at a small scale, normally 1:50 000. Not all the Environment Agency Regions have published these, but the Environment Agency is currently engaged upon a national programme of surveying flooding problems and mapping flood plains at a

larger scale.

Information about flooding can be obtained from the Environment Agency Regional Offices or from:

The Flood Defence Officer
The Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS12 4UD.
Tel 01454 624400.

The Environment Agency general enquiry telephone line for local public registers is: 0645 333 111.

30a The Institute of Hydrology (for the IoH address see **21**) provides information, on a 50m grid, of estimated flood depth in an event with a 100 years return time, in the absence of flood defences. IoH also maintains the National River Flow Archive, a public domain database and part of its National Water Archive. There is a charge for commercial use, but for research, costs depend only on the handling charge for tracking down and sending out the data. The National River Flow Archive can be accessed (generally) by clicking on the National Water Archive button on the Web site: http://www.nerc-wallingford.ac.uk/ih/

31 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. The geographical areas covered in Britain are variable. 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.

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.

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 (see **30a**). Some of these

spatial data are digital and some are in time series. These data, combined with hydrogeological information, are used for a full understanding of aquifers and their recharge potential. The principal contact for information is:

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

32 & 32a see **8**

Digital overviews of the extent of alluvium and the distribution of deposits overlying aquifers are shown on the BGS 1:625 000 scale maps of Solid and Drift geology.

33 see **2a**

33a Nitrate Vulnerable Zone maps can be obtained by contacting the relevant MAFF Regional Service Centre. The addresses of these MAFF Centres are:

Anglia Regional Service Centre (MAFF)
Block B, Government Buildings
Brooklands Avenue
Cambridge CB2 2DR.
Tel 01223 462727.

East Midlands Regional Service Centre (MAFF)
Block 7, Government Buildings
Chalfont Drive
Nottingham NG8 3SN.
Tel 0115 9291191.

North East Regional Service Centre (MAFF)
Government Buildings
Crosby Road
Northallerton
North Yorkshire DL6 1AD.
Tel 01609 773751.

Northern Regional Service Centre (MAFF)
Eden Bridge House
Lowther Street
Carlisle
Cumbria CA3 8DX.
Tel 01228 523400.

North Mercia Regional Service Centre
MAFF
Electra Way
Crewe Business Park
Crewe
Cheshire CW1 6GJ.
Tel 01270 754000.

South Mercia Regional Service Centre (MAFF)
Block C, Government Buildings
Whittington Road
Worcester WR5 2LQ.
Tel 01905 763355.

South East Regional Service Centre (MAFF)
Block A, Government Buildings
Coley Park
Reading
Berkshire RG1 6DT.
Tel 0118 9581222.

South West Regional Service Centre (MAFF)
Clyst House
Winslade Park
Clyst St Mary
Exeter
Devon EX5 1DY.
Tel 01392 447400.

Wessex Regional Service Centre (MAFF)
Burghill Road
Westbury-on-Trym
Bristol BS10 6NJ.
Tel 01179 591000.

34 see **1**

Conservation Data

35 to 35d

English Nature provides maps concerning relevant geographic information in hard copy and digital format. The digital datasets are drawn to a basic scale of 1:10 000 and many can be downloaded from the Internet in a format suitable for GIS (see http://www.english-nature.org.uk/start.htm). The contact address is:

Geographic Information Unit
Information Systems Team

English Nature
Northminster House
Peterborough PE1 1UA.
Tel 01733 455332
Fax 01733 455328.
Web http://www.english-nature.org.uk/start.htm

14 colour paper maps at 1:200 000 cover the entire country. They cost £16 each plus post & packaging. They are updated monthly. These maps and others at smaller scales (see the English Nature Web site for details) are available from:

Telelink Limited
P.O. Box 100
Fareham
Hampshire PO14 2SX.
Tel 01329 331300
Fax 01329 330034.
E-mail reception@telelink.co.uk

36 The Countryside Commission has information on Areas of Outstanding National Beauty (AONBs) and National Parks. The Web site is very useful at:
http://www.countryside.gov.uk/

Lists of publications can be obtained from:

Countryside Agency Postal Sales
P.O. Box 124
Walgrave
Northampton NN6 9TL.
Tel 01604 781848.

37 English Heritage maintain a database of the location of ancient scheduled monuments and their grounds. The information is currently being incorporated into a GIS entitled Heritage Spatial Information Service (HSIS). There will be a charge to access this GIS. The address is:

English Heritage Records Office
23 Saville Row
London W1X 1AB.
Tel 0171 973 3100.

38 Local authority planning departments keep maps of Green Belt areas. Green Belts are designated areas protected from new development and house building.

39 The Institute of Terrestrial Ecology (ITE) manages a number of key projects concerning survey mapping of ecology, soil types, soil quality, land cover and vulnerability to acid deposition from the atmosphere (critical load maps). In particular, ITE runs the **Countryside Information System**. The CIS is a PC-based information system running under the Microsoft Windows operating environment,

developed under contract to the Department of the Environment. It provides easy and flexible access to information on land cover, landscape features, vegetation, soils and freshwater animals from the Countryside Survey 1990. The CIS stores, analyses and displays data by the 1 km squares of the British National Grid. Two types of data are held: census data which are available for each 1 km square in the country (eg designated and administrative areas and boundaries, Land Cover Map) and sample data which are referenced to the ITE land classification (eg land cover stock and change 1978, 1984 and 1990; and linear features stock and change 1984 and 1990). Any other types of census or sample data which can be related to the 1 km square framework can be used in the CIS. Data can be output as hard copy maps, tables and simple charts, or copied within Windows to other spreadsheets, graphics or desktop publishing software. Much more detailed information on the ITE surveys and data holdings can be found on the Web site below. The address is:

Institute of Terrestrial Ecology
Monks Wood
Abbots Ripton
Huntingdon
Cambs. PE17 2LS.
Tel 01487 773381
Fax 01487 773467
Web http://mwnta.nmw.ac.uk/ite/edn2.html

40 Information on Environmentally Sensitive Areas (ESAs) can be found from:

MAFF
North Regional Service Centre
Edenbridge House
Carlisle CA3 8DX.

The Farming and Rural Conservation Agency acts for MAFF and is a useful contact:

FRCA Headquarters
Nobel House
17 Smith Square
London SW1P 3JR.
Tel 0207 238 5432
Fax 0207 238 5588.
E-mail: frca.gen.enq@frca.maff.gov.uk
Web (general): http://www.maff.gov.uk/aboutmaf/agency/frca/frca.htm
Web (on ESAs): http://www.maff.gov.uk/environ/envsch/esa2.htm

APPENDIX 4 SOURCES FOR MINING DATA IN GREAT BRITAIN

INTRODUCTION

This Appendix of information has been gathered from many disparate sources and is only intended as a guide to some of the mining data in Great Britain. The listings are in no way comprehensive and have relied mainly on an individual's knowledge of areas where they have worked or data they have seen. Where only the name of the organisation is given no knowledge exists of the type or extent of the data. If the nature of the collections is know then some basic details are given.

SOURCES

1. *CENTRAL ARCHIVES*

1.1. British Geological Survey

Coverage of the whole country

Records of boreholes, shafts and adits in the Borehole Records collection and on field maps and in notebooks.

Extensive Library archives and publications such as Hunt's 1858 memoir and the modern Directory of Mines and Quarries.

An ex-British Coal donation of assorted plans related to coal mining, (c. 20,000).

Scotland and Northern England

Plans of Abandoned Mines (Other than Coal & Oil Shale) for Scotland, (c.610 plans).

Plans of Abandoned Mines (Other than Coal) for Cumbria, (1240 plans).

Microfilm copy of Plans of Abandoned Mines (Coal & Oil Shale) for Scotland, (c. 7800 plans). Original plans held by the Coal Authority, Bretby.

Land Survey Plans (LSP). Mine plans from various sources including some 500 non-coal plans deposited by NCB. (Total c.1300 plans)

England and Wales

Originals and copies of plans relating to mine workings. Includes abandonment plans, mine entry data and synthesis or interpretations of data from other sources. All indexed on computerised database allowing geographic searches. (Total 10,044 plans)

Other mining data including plans is held in Borehole Records collection; organised in OS 1:10K quarter sheet order. (Quantity unknown)

Mining data is also held in the miscellaneous archive collection organised by OS 1:50K geological sheet area or OS 1:10K quarter sheet. (Quantity unknown)

1.2 Health and Safety Executive

The HSE is responsible for ensuring the deposit of plans of mines on abandonment and keeping the catalogue is kept up-to-date. The HSE is the body responsible for all mine abandonment plans and BGS, County Records Offices and the Coal Authority hold plans on the behalf of the Executive. In the past they have published lists of abandoned mines and a listing of current working mines.

1.3 Coal Authority, Bretby

Deep mine and open-cast coal records and borehole records. All coal mine abandonment plans, including some non-coal plans and Scottish Oil shale plans. (Total over 100,000 plans.) Open-cast coal exploration data (quantity unknown).

1.4 Scottish Record Office (SRO), Edinburgh.

Register House Plans (RHP). Contain a number of mine plans, the bulk of which are of 20th C. coal mining, but some of earlier date. Those dated prior to 1872 may not be covered by mine abandonment plans.

Large deposit by British Coal, c.1994-5, of plans formerly held at CRA Newtongrange, (c.26,000 plans). Consists of duplicates of abandonment plans held by the Coal Authority, Bretby.

2. *REGIONAL ARCHIVES*

Coverage of the whole country

The regional offices of the **Mineral Valuer** have data collected from a wide range of sources including libraries and individuals. The majority of the data are not original records. Information, such as visits to mine sites, is also on file.

England and Wales

During 1989-90 the **Health and Safety Executive** dispersed its collection of non-coal mine plans to the **County Record Offices** in England and Wales. Any plans produced subsequently will have been deposited directly with these offices. Listings of some 4000 plans were obtained in 1993 from the following counties:

Avon	Devon	Hereford &	Northumberland
Birmingham	Durham	Worcester	Nottinghamshire
Cheshire	Dyfed	Lancashire	Powys
Cleveland	Glamorgan	Leicestershire	Shropshire
Clwyd	Gloucestershire	Lincolnshire	Somerset
Cumbria *	Gwent	Manchester	South Yorkshire
Derbyshire	Gwynedd	North Yorkshire	Staffordshire

Surrey		Warwickshire	Wiltshire	*(HSE plans at
Tyne	&	West Midlands	Wolverhampton	BGS)
Wear		West Yorkshire		

In addition, a number of the County Records Offices already had collections of mining data and include **Northumberland CC** (data from several counties), **Wakefield MDC** (several thousand manuscript items relating to approximately 100 collieries in the west riding 1330-1947), **Walsall MBC** (plans c.1850-1930), **Glamorgan** (colliery plans).

West Yorkshire Highways and Technical Services. Plans and mine entry data for West Yorkshire. Good quality information often actually surveyed in on the ground.

Cheshire Brine Compensation Board. Deals with all enquiries to do with brine extraction in Cheshire or Greater Manchester, Droitwitch (Hereford or Worcester)

North of England Institute of Mining and Mechanical Engineers. Mining maps and plans mainly from Northumberland and Durham. Includes Watson Collection 1745-1832 with over 700 plans.

Newcastle-Upon-Tyne, Central Library. Large collection of local mining maps and plans.

Scotland

Local authority archives and libraries may hold mine plans, but the collections are unlikely to be of significant size. The following are known to hold mine plans.

Strathclyde Regional Archives, Mitchell Library, Glasgow. Mine plans contained in deposits from various sources, e.g. Duke of Portland collection. Mostly covered by mine abandonment plans.

Monklands District Library, Airdrie. Small collection of ironstone and coal plans for Airdrie district; possibly former **William Baird & Co.** plans. BGS has rough tracings of these; (LSP 1443-1459).

Hamilton: Central Library Records of Lanarkshire estates including c. 400 colliery plans; see also estates below.

3. *COMPANIES AND CONSULTANTS*

3.1 Operating companies

England and Wales

A large number of companies will have current operating plans and plans of mines not yet put into abandonment. These can relate to older workings and examples of

companies holding data relating to mining which ceased over 50 years ago are not unknown. Examples of larger holdings: **RJB Mining, ICI** (Anhydrite),**ECC, British Gypsum and British Steel** (Abandonment plans and ironstone workings in the Cleveland Hills)

3.2 Consultants and solicitors

Coverage of the whole country

In 1990 a review of mining instability was carried out by Arup Geotechnics, the Geotechnical Consulting Group of **Ove Arup and Partners.** There were three volumes with summary maps and they included ten regional reports, one for each Planning Region in England and one each for Scotland and Wales. The data are still held by the company.

England and Wales

Johnson Poole and Bloomer. Extensive collection of data for the Midlands.

Fennell, Green and Bates. Large collection of old mine plans mainly of fireclay workings, Bradford /Leeds area.

Ove Arup and Partners. Data gathered for DoE contract on Limestone mines in Dudley, West Midlands.

Cornwall Consultants. Data unknown but recommended source by the Law Society for land in West Devon or Cornwall likely to be affected by tin mining.

Scotland

J.W.H. Ross & Company, consulting mining engineers, Glasgow, hold a collection of mine plans, mainly copies. Succeeded to D.&.G.R. Rankine many of whose plans are not covered by the abandonment plan collections.

J.& J. McCosh, solicitors, Dalry: Ayrshire coal and ironstone plans.

4. SPECIALIST SERVICES FOR MINING INFORMATION

Bristol Coal Mining Archive: Extensive collection for the Bristol Area

Plansearch-UK: Nationwide coverage with some 1 million plans, but specialises in Staffordshire. The majority of the plans are thought to be copies but may be difficult to source elsewhere.

IMMAGE: The **Institute of Mining and Metallurgy** provides an on-line worldwide source of mining data. Probably includes the **Hall's Index** of references to individual mines in the Mining Journal , which is available for internal use in the BGS Library.

5. *PRIVATE AND OTHER MISCELLANEOUS SOURCES*

5.1 Landowners

Landowners may hold mine plans amongst estate papers. For example:

England and Wales

National Trust
Duchy of Cornwall: mainly 19th Century tin, copper and silver mines in Cornwall.
Duchy of Lancaster

Scotland

Many surveyed and listed by the National Registry of Archives (Scotland), NRA(S), based at SRO. The following are known to hold mine plans.

Hopetoun Estate: lead mine plans for Leadhills.
Buccleuch Estates: mine plans Wanlockhead.
Kinneil & Hamilton Estates Ltd, Hamilton: coal and limestone plans, W.Lothian, Lanarkshire, etc.
Prestonhall Estate: limestone plans, Pathhead, Midlothian.

Most of the larger private collections have been listed by the NRA(S).

5.2 Speleological Societies: e.g. Chelsea

5.3 Museums: several museums have mining plans and data, for example:

Lancashire Mining Museum, which includes the **Wigan Mining Library**.

5.4 Academic Institutions

Extensive archive of mining in Cornwall held by the **Cambourne School of Mines**
University of Nottingham Library- Coal mining information for Nottinghamshire and Derbyshire.

In addition to the above, small amounts of data may be held by **RIGS/NSGSD** offices.

CONCLUSION

This report has concentrated on mine plan data as the most direct source of mining information. This information is very scattered with numerous source collections. Other mining data are even more widely spread.

Prepared by R C Bowie
NGRC, BGS, Keyworth
4 August 1997, with minor revisions Friday, 23 July 1999.

APPENDIX 5 ENVIRONMENT AGENCY GUIDES TO INFORMATION

The Environment Agency has provided information on the Web (www.environment-agency.gov.uk and www.environment-agency.wales.gov.uk), and also pamphlets that are guides to finding information available to the public. Two that are of particular help are:

- Public Registers of Environmental Information;
- Access to Environmental Information.

The first listed guide is helpful for guidance on any costs that may be incurred when obtaining Environment Agency datasets. Inspection of public registers is free of charge. Where copies of documents are supplied these are free except for large and complicated requests that entail more than £50 of staff time and materials. Charges will be agreed in advance. Charges made for the provision of information are not subject to value added tax (VAT).

Requests for environmental information should be made to the Customer Services Centre at the local Environment Agency Area Office. The address and telephone number of the local office can be obtained by telephoning the general enquiry number (tel. 0645 333 111). Requests are preferred in writing, especially if they involve complicated datasets.

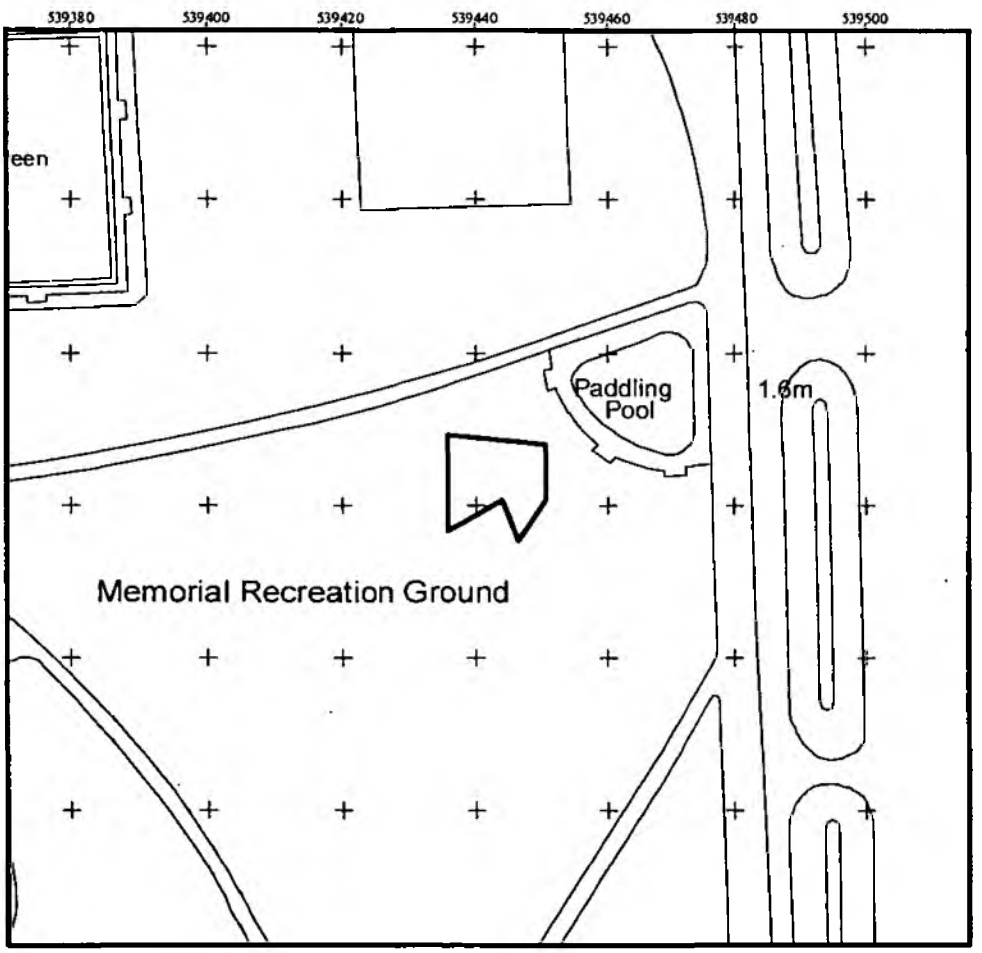
APPENDIX 6 EXAMPLE OUTPUT FROM THE REPORT GENERATOR

The Report Generator output example below is derived from the customised ArcView GIS developed for the London Borough of Newham. It is intended for display purposes only within this report.

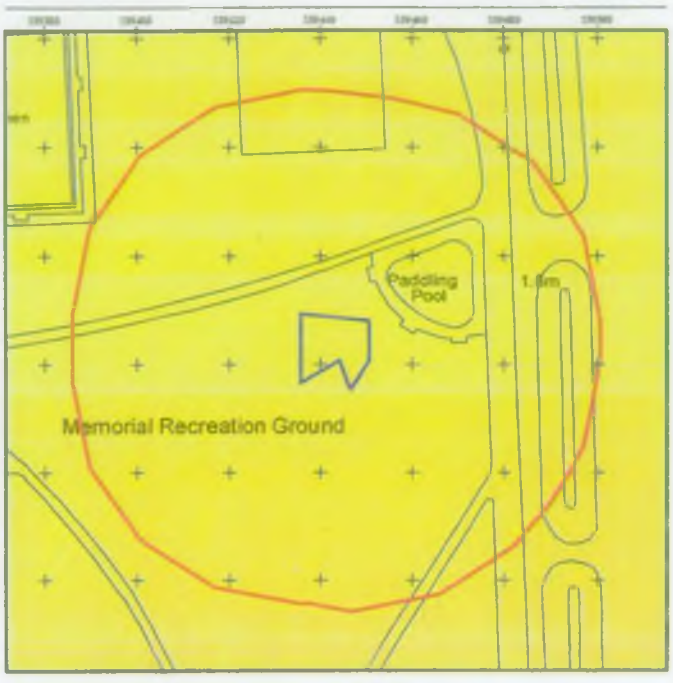
REPORT GENERATOR

Site Name: Example Site
Location: (539443, 182782)
Date: 15 December 1999

Location of Site



Geology (Site Name: Example Site, Search Radius: 50m)



Geology of Site

Solid:	London Clay,
Superficial Deposits:	Alluvium,
Artificial Deposits:	None
Boreholes:	None

Geology of Search Radius

Solid:	London Clay,
Superficial Deposits:	Alluvium,
Artificial Deposits:	None
Boreholes:	None

Pre 1900 Land Use (Site Name: Example Site, Search Radius: 50m)

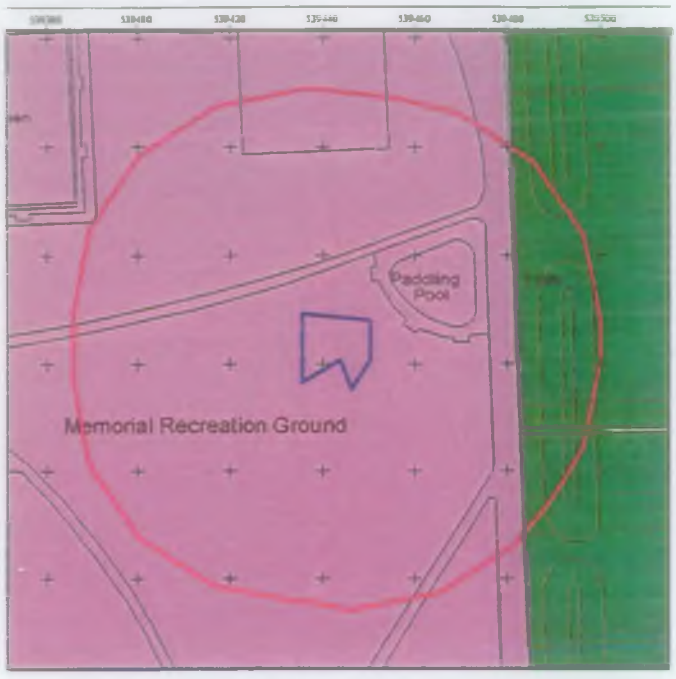
Pre 1900 Land use within Site

None

Pre 1900 Land use within search radius

None

1920's Land Use (Site Name: Example Site, Search Radius: 50m)



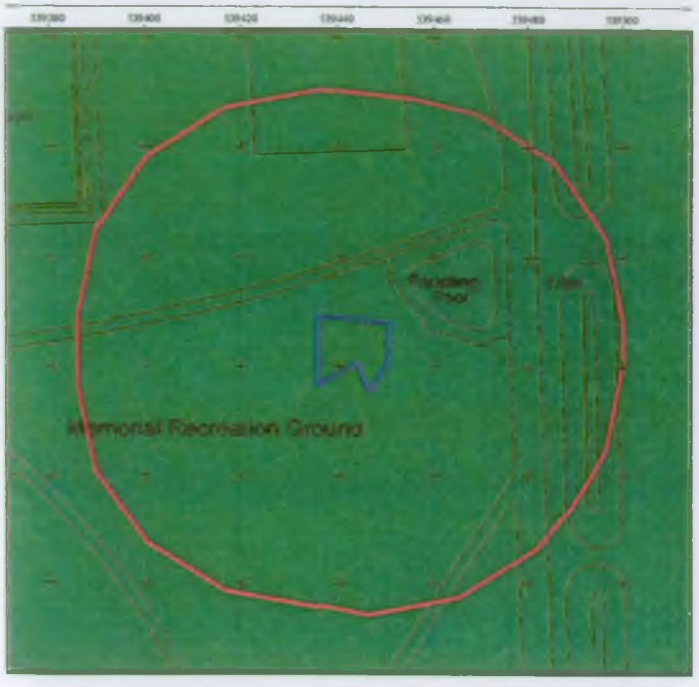
1920's Land use within Site

MAIN_USE	DETAILS	COMMENTS	EASTING	NORTHING
Vacant Land			539337.9	182729.7

1920's Land use within search radius

MAIN_USE	DETAILS	COMMENTS	EASTING	NORTHING
Open Areas	Memorial Athletic Ground		539554.9	182891.9
Open Areas	Allotment Gardens		539562.9	182694.9
Vacant Land			539337.9	182729.7

1960's Land Use (Site Name: Example Site, Search Radius: 50m)



1960's Land use within Site

MAIN_USE	DETAILS	COMMENTS	EASTING	NORTHING
Open Areas	Public open space		539474.8	182832.0

1960's Land use within search radius

MAIN_USE	DETAILS	COMMENTS	EASTING	NORTHING
Open Areas	Public open space		539474.8	182832.0

Important