

National Soil Resources Institute, Cranfield University

NSRI Technical Capability Statement



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Change History

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NSRI and Cranfield University

<http://www.cranfield.ac.uk/sas/> <http://www.landis.org.uk>

The **National Soil Resources Institute (NSRI)** is a part of the Department of Natural Resources within the School of Applied Sciences at Cranfield University with some 50 staff and is an applied research and consulting group dedicated to providing solutions for a variety of environmental projects. NSRI holds the soil information for England and Wales and is the official body responsible for collecting and evaluating information about soils, their distribution, properties, behaviour, quality and use in these countries. The Institute has unique information, assets and expertise relating to soil science. Its status as a leading authority on soils has been recognised by the UK Government which has formally appointed NSRI as the UK National Reference Centre for Soil, part of the network of environmental centres co-ordinated by the European Environment Agency.

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NSRI leads Cranfield's research on soil, specifically by:

- Understanding the physical, chemical and biological processes that make up soil systems and that provide capacity for soil-based ecosystem services;
- Creating, maintaining and exploiting inventories and monitoring systems for soil resources;
- Describing processes that expose or protect soils from threats (e.g. organic matter loss, erosion, contamination, compaction, loss of biodiversity and sealing), and developing policy and better technology for soil management and conservation in both rural and urban areas, including for sports surfaces;
- Applying engineering design and evaluation methods to improve the performance of off-road vehicles, construction equipment and agricultural machines.

From managing its large information base, NSRI has gained considerable understanding of storing, manipulating and analysing spatial and non-spatial data sets, of developing environmental modelling solutions to represent thematic soil-based properties, and of using industry-standard tools such as Geographic Information Systems (GIS) and relational (RDBMS) database management systems. NSRI has a long heritage in the management of national environmental datasets, and manages, on behalf of the UK Ministry Defra, the Land Information System (LandIS) (<http://www.landis.org.uk>). NSRI offers high levels of expertise in the design, implementation and subsequent operation and development of a wide variety of leading-edge and industry-standard GIS and related spatial technologies.

In the UK, much of the work of NSRI is focussed upon the Agriculture, Environmental and Utilities (Water, Electricity and Gas) sectors. This experience is used, for example in the Water Industry, to provide decision-support systems for catchment management, for avoiding pesticide contamination of surface and ground water, and corrosion of ferrous pipework and other underground assets. In the Agro-Chemical Industries, NSRI expertise is used to ensure registration of 'safe' pesticides only and in mitigating pollution from other organic contaminants such as nitrates and phosphates.

NSRI has conducted agricultural, land resource development and environmental protection themed research and consultancy projects in many parts of the world. Some 10 – 15 percent of the Centre's work programme is undertaken outside the UK, where applied research activities are undertaken to develop optimal land use strategies and thematic soil assessments – often based around the unique World Soil Survey Archive and Catalogue (WOSSAC) (<http://www.wossac.com>) operated by Cranfield. NSRI's client list includes the UK Ministries of Agriculture and Environment, the major UK Utilities (Water, Electricity and Gas), the UK Environment Agency, the European Environment Agency, the European Commission, the Government of Turkey, and multi-national companies such as Monsanto, Zeneca, Rhône-Poulenc and BASF. Outside Europe, NSRI experts have worked in Venezuela, Ethiopia, Tanzania, Jordan, Kuwait, Pakistan, Bangladesh, Thailand, Indonesia, the Levant and India.

NSRI staff play key roles in the ongoing work of the European Soil Bureau Network operated by the European Commissions Joint Research Centre at Ispra in Italy. This group was formed to permit exchange of ideas and best-practices on all aspects of the conduct of soil-related activities across all member states. Today the ESNB operate a number of working groups specialising in key issues, and with memberships representing Cranfield.

Cranfield University

NSRI is located within the Natural Resources Department of the School of Applied Science within **Cranfield University** (<http://www.cranfield.ac.uk/sas/>), one of the leading technical Universities in the United Kingdom. NSRI is also able to offer access to the wider capabilities of the University, benefiting from internationally renowned expertise in civil engineering, agriculture, biotechnology, biomedicine, design, manufacturing, aerospace, materials technology and management. This expertise is centred on a broad range of research, consultancy, training and education programmes. Cranfield University offers post-graduate and specialist undergraduate teaching as well as bespoke training solutions and short courses. The University prides itself on its excellent academic teaching record and its leading-edge industry-based research.

Field Soil Survey Capabilities

The National Soil Resources Institute (2002+) and its predecessor organisations, the Soil Survey of England and Wales (1939-1987) and before this, the Soil Survey and Land Research Centre (1987-2002) have successively had the responsibility for mapping the soils of England and Wales for over 65 years. Initially (from 1939-1966) field mapping was undertaken at a scale of 1:10,000 and the resulting maps published at a scale of 1:63,360. Some ten percent of the two countries were covered at this scale. In the period 1966-1979 field mapping was conducted using field sheets at 1:10,000 or 1:25,000 scale, for publication at 1:25,000 scale. Over 100 maps at a scale of 1:25,000 have been published.

In 1979 the mission of the Soil Survey of England and Wales was directed towards producing a national map of the soils of England and Wales at a scale of 1:250,000. Fieldwork was concentrated in previously unsurveyed areas, recording observations by small pits or auger borings to a depth of 1 metre at an average of 3 per square kilometre. In some areas transects were made to represent particular patterns of landscape and geology; in others sample farms were surveyed. All observations including auger borings were recorded using computer compatible techniques and all data relating to this programme have been maintained. This mapping programme was completed in 1983 having produced coverage of the whole of

England and Wales. This last mapping programme formed the basis for subsequent maps at a range of smaller scales.

During this extensive experience of soil mapping, experiments have been undertaken with different types of mapping procedure. Most of the mapping has been using *free survey* in which field observations are sited purposively to check or plot boundaries in accordance with a pre-determined mapping legend. The use of *grid surveys* in which boundaries are based on interpolation between regularly spaced, pre-determined sampling points has also been tested. *Physiographic survey* techniques of mapping have also been tested but while having the advantages of speed and cheapness the end result is necessarily limited.

In the last decade there has been much attention given to digital mapping leading to computer assisted production of digital maps of soil type and soil properties. NSRI has a strong programme in this area using mathematical and statistical models, combining field survey information with information contained in correlated environmental variables and remotely sensed images.

Allied to, and very much dependent on the field surveys, have been several other significant developments. A Soil Survey Field Handbook was produced which has been used widely in other parts of the world and is a vital accompaniment to field mapping. The 1:250,000 mapping programme completed in 1983 has been a vital base for the production of capability maps for a very wide range of soil users. Accompanying the soil mapping programmes has been the establishment of a highly respected computerised Land Information System (LandIS).

NSRI thus has a long experience of mapping soils. It is a dedicated member of the European Soil Bureau Network and works within it to improve the mapping of soils within the European Community.

Soil Analysis and Sample Management

The School of Applied Sciences operate a state-of-the-art custom-equipped facility for soil testing and investigation, managed by the Natural Resources Department. The laboratory is only used by staff and registered students within the School under the supervision of a departmental manager.

Laboratory layout and facilities

The ground floor of the building is divided into a number of areas:

- **Sample reception:** An area is assigned for the receipt of soil material. Samples are identified uniquely and stored within this room before subsequent preparation and analysis.
- **Sample preparation:** Most soil material requires preparation before analysis. This area houses drying and specialised grinding facilities.
- **Soil physics:** A separate area has been created for physical investigation of soils, such as determination of soil strength and water holding characteristics.
- **General purpose area:** The remainder of the ground floor laboratory consists of facilities for carrying out soil extractions and determination such as particle size distribution and soil pH. The design of the laboratory includes a partitioned space that can be utilised for the taught laboratory modules of MSc courses whilst allowing for the continuation of research work in the rest of the facility.

The first floor laboratory area houses sophisticated analytical instrumentation for the direct analysis of soil and water samples.

Soil Analytical Training

The soil laboratory supports MSc taught courses, PhD and contract research. The laboratory has been involved in the MALSIS project, noted below, in supplying training in performing laboratory analyses on a national survey of Malta including sample management systems.

Soil Inventory and Monitoring

The Natural Resources Department has many years experience of soil inventory and monitoring. We instigated the National Soil Inventory (NSI) to obtain an unbiased estimate of the distribution of the soils of England and Wales and of the chemistry of the topsoil. The NSI is based on a 5-km grid (approx 6,000 sites) covering all soil types, habitats and land uses. The original sampling (1978-83) was repeated at approx. 40% of sites 12-25 years later in such a way as to detect a specified change in the soil with specified confidence. It is unique among national soil inventories globally in having been comprehensively resampled. Samples of air-dried soil from both samplings are held in an archive. Data from both samplings are held in LandIS the Natural Resources Department database system. The data from the NSI has been used to investigate the spatial variation in all the measured properties. In collaboration with RRes and BGS we carried out an investigation into the spatial and temporal variation in the chemical properties of soil using the NSI original and resampled data and data from BGS. This showed how multivariate geostatistical methods can be applied to the analysis of multitemporal data. We analysed the organic carbon data from the NSI and showed that there had been a large loss of carbon from the soils across England and Wales (Bellamy et al 2005).

We have carried out several projects on assessing sampling strategies for soil monitoring: investigating the geographical reliability with which sampling sites could be revisited and carrying out field sampling to investigate the local variability of several soil properties.

In collaboration with organisations such as CEH and ADAS we have investigated the comparability of soil properties derived from different data sources. In one project, we examined four national datasets of soil analyses - the National Soil Inventory (NSI), the Representative Soil Sampling Scheme (RSSS), the Countryside Surveys (CS) and the Environmental Change Network (ECN) - and examined the differences between them.

We have developed performance criteria for soil monitoring schemes which set out the criteria necessary to enable a soil monitoring scheme to be designed. In collaboration with the Macaulay Institute, RRes, BIOSS, CEH and AFBI Northern Ireland we are currently designing a soil monitoring scheme for the whole of the UK. This project aims to develop a UK monitoring scheme and framework for delivery that is based on the indicators of soil function previously identified and which can assess the current status of soils and changes over time at a UK and devolved administration level.

The Natural Resources Department led a key EU FW6 project, entitled ENVIRONMENTAL ASSESSMENT OF SOIL FOR MONITORING (ENVASSO). This high impact project addressed the needs of EU Environment Task 6 (Characterisation of soils) by setting a series of interlinked objectives that will lead to the harmonisation of the soil datasets that currently exist in EU member states. The project call was for a holistic approach to soil protection through the robust and defensible selection of criteria, thresholds and indicators based on harmonised approaches to soil information collection, analysis and management. This approach is

encompassed within ENVASSO through the consideration of real, existing data, interpretation, and approaches to soil inventory / monitoring. ENVASSO distilled this knowledge, expertise and leading-edge methodologies to create a working prototype database structure, and Procedures and Protocols for harmonised soil assessment throughout Europe. The project ran from January 2006 to December 2007 (<http://www.envasso.com>).

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Digital Soil Mapping

Research into soil-landscape relationships and environmental modelling at the National Soil Resources Institute, formally the Soil Survey of England & Wales, goes back to 1994 when the first MSc study was undertaken to establish new techniques to fill the current gaps in detailed mapping. Initially a range of MSc projects looked at different data mining techniques such as Discriminant Function Analysis, Decision Graphs, Decision Trees, Neural Networks and Bayesian Belief Networks and currently investigating model-based geostatistics.

This was followed by two major project sponsored by DEFRA on the feasibility of digital soil mapping techniques and extending the approach to digital mapping of soil functions using a wide range of models covering almost 2,000 km². The Institute is currently undertaking a two year study for the Joint Research Centre of the European Commission for demonstrating the entire digital mapping process from raw data to soil functions utilising spatial inference, soilscape inference (pedo-transfer functions) and soil functions (biomass) modelling covering an area of 10,000 km².

In September of this year, two commercial projects are expected to be started, using Digital Soil Mapping techniques to provide important soil-related information for Utility companies, covering a total area of 58,000 km².

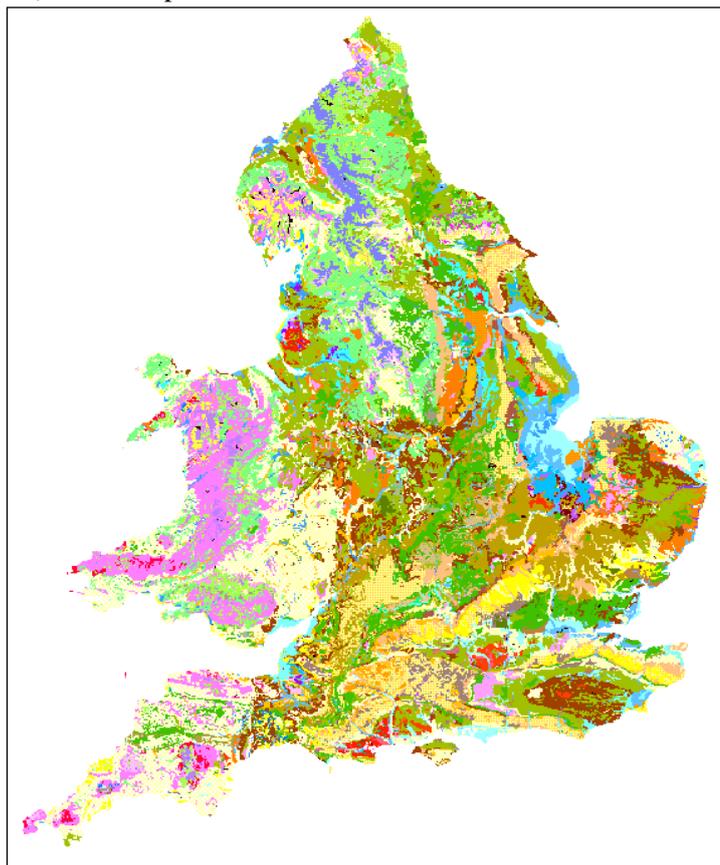
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Soil Information Systems and Spatial Data Infrastructures

NSRI has significant experience with the development of mainframe and minicomputer-based information systems as well as systems running on Windows and Unix-based server platforms. It has developed the Land Information System, 'LandIS', (<http://www.landis.org.uk>) incorporating soil and related data, and a knowledge base collected over the last 60 years in the UK and Europe. Today, LandIS is one of the most sophisticated information systems of its kind in Europe. Hosted in the Oracle 8i relational database management system and using ESRI's Spatial Database Engine (ArcSDE), LandIS includes digital versions of the National Soil Map (at 1:250,000 scale) and the National Soils Inventory (NSI) (a 5km x 5km sampling programme) with comprehensive information about soil, site, and land use. LandIS also includes point and spatial information on related land use/cover, geology, climate and hydrological characteristics.

NSRI has also developed a number of computer-based systems to support strategic decision-making. These systems, based on LandIS data, address land evaluation, soil degradation, catchment-based water resource management, pollutant transfer (e.g. predicting the fate of biocides) and geotechnical issues such as ground stability (risk of building foundation subsidence and of corrosion of buried pipe assets). Many of these systems employ graphical user interfaces (GUI) and have specific modelling capabilities. At the European level, NSRI has been involved in projects, funded by the European Union, to study the fate and behaviour of applied agrochemicals and the development of low-input farming systems. Overseas, NSRI has an established reputation in the design, specification and implementation of environmental information systems as well as staff training and project support services.



Cranfield University, through NSRI and other University units, has long recognised the importance of metadata to enable the maximum value to be obtained from the investment in such computer systems and their data holdings. The commitment to providing metadata is evidenced through NSRI's participation in the UK NGDF Metadata Working Party, particularly representation on the ISO Technical Committee TC211 Functional Standards project team relating to Metadata, Feature Cataloguing and Profiles, as well as membership of the Open GIS Consortium.

Key references

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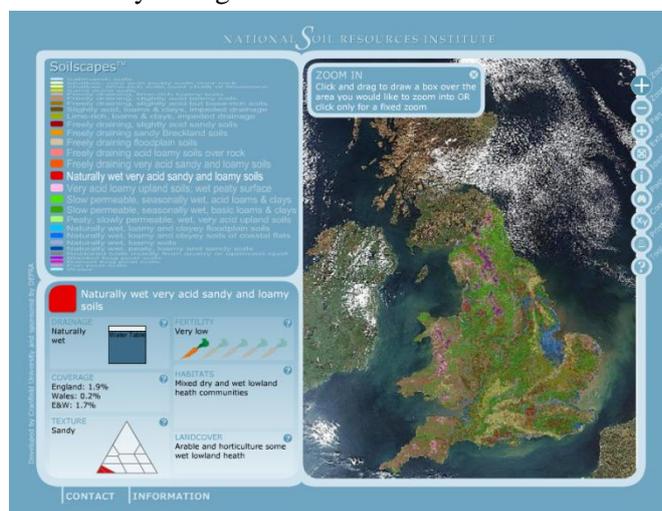
Standards Compliance and Interoperability

NSRI has developed a strong core competency in developing environmentally-focused Spatial Data Infrastructures (SDIs) which are informed by emergent international standards for data exchange and interoperability.

Information systems work underway in NSRI incorporates the development of system architectures designed to allow a 'clearinghouse' approach to external data consumers, using web mapping services (WMS) and web feature services (WFS) to provide information from the Land Information system (LandIS) either as raw data, or as pedo-transfer functions (PTFs).

Metadata information structures are in use within LandIS which are consistent with 'ISO19115' for mapping and imagery, and both 'Dublin Core' and 'MARC21' for documentary materials.

GEOSS is a user-driven "system of systems". It addresses in-situ, airborne and space-based observing systems with arrangements to make them interoperable and to share resulting data and derived products. It covers the whole processing cycle from primary observation to information production including archiving and distribution. It ensures that shared observations and products are accessible, comparable and understandable by supporting common standards adhered to by GEO contributors. Cranfield is working as a partner organisation for the [GEOSS Architecture Implementation Pilot](#) project, in provision of soil-related thematic data for the 'Ecosystems and Biodiversity in Africa Scenario'.



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Laxton, J. & Rackham, L. & Murray, K. & Hallett, S.H. & Simmons, J. (2009) "DNF Reference Base Sub-Group – 2009. The Rationale and Objectives for extending the DNF Reference Base. A DNF White paper. 17pp."

Web-based information services

Cranfield has experience in the development of a wide range of standards-compliant and custom web-based services to reveal the data holdings to a wide audience over the Internet. These include:

Soilscapes Viewer

The Soilscapes viewer provides online users with free access to a simplified soil map of England and Wales, and allows locations to be interrogated by UK Postcode or by grid reference. The viewer then produces a simple site summary indicating such information as soil texture and soil fertility. The Soilscapes soil classification was selected as a 24 class classification which is more accessible than the full national soil map legend.

A further development of the Soil Site Reporter is the Soilscapes Primary viewer, incorporated into the Cranfield educational web portal (<http://www.soil-net.com>). This has a 12 class classification and is designed to be appealing to young schoolchildren.



Soil Site Reporter

The Soil Site Reporter offers users the ability to generate one of a number of detailed thematic reports for a specific location identified by Postcode, gazetteer or grid reference. This report contains some 43 pages of information in a PDF format document. The report contains detailed and comprehensive descriptions of proximal: Soil types; Soil properties; Risks caused by the soils, and; Diagrams and interpretation.

Soil Archives

Over the past 80 years, extensive soil, land use, land resource and land suitability surveys have been undertaken worldwide by British companies and soil surveyors and scientists in response to the various needs of overseas territories. It was brought to the attention of the Tropical Agriculture Association (TAA) and the British Society of Soil Science (BSSS) that many of these surveys were in danger of being lost or destroyed, as donor funding agencies were subject to reorganisation, companies producing the soil surveys acquired, merged, downsized or closed, and the surveyors themselves retired. Action was required to ensure these reports were not lost for ever. The World Soil Survey Archive and Catalogue, WOSSAC, was created in 2004 at Cranfield University, UK, supported by BSSS to preserve, archive and catalogue and to make available as many such soil survey reports as possible. Such archives are extremely important given the costs which would be incurred to repeat the surveys today. For many



countries these reports represent the only detailed scientific studies of their soils and potential use.

Today, WOSSAC represents an extensive collection of soil, land resource and land suitability surveys undertaken worldwide over the last 80 years by soil surveyors and scientists at the behest of the British government and others has been archived and catalogued using internationally recognised bibliographic standards. WOSSAC consists of over 13,000 soil-related reports and maps is now available for consultation and use by the international soil science community via the project Internet portal <http://www.wossac.com/>.

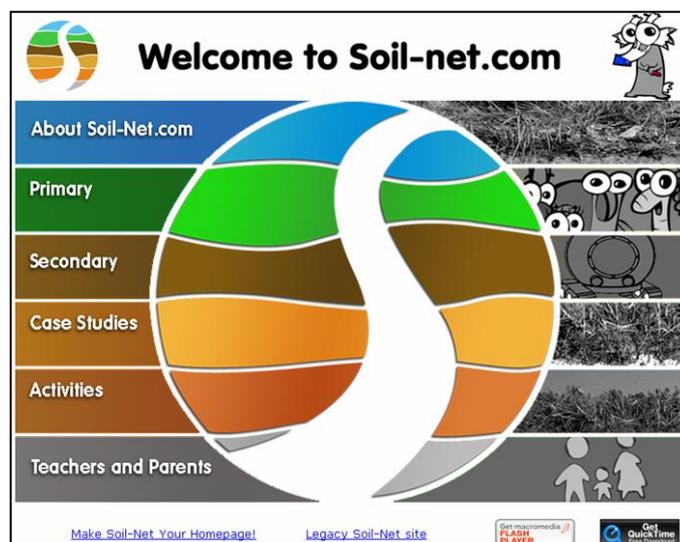
Key reference

Hallett, S.H. & Bullock, P. & Baillie, I. (2006) "Towards a World Soil Survey Archive and Catalogue", *Soil Use And Management*, 227-228. 3

Soil Education and Awareness

Cranfield University offer a broad range of environmentally-themed Postgraduate courses at Masters (online at <http://www.cranfield.ac.uk/sas/masters/>) and Doctoral levels, as well as a range of Continuing Professional Development (CPD) courses (online at <http://www.cranfield.ac.uk/sas/short/>) and seminars. Masters courses cover many topics including environmental engineering and management (natural resources, land and water) as well as geographical information management (GIS and remote sensing).

To support a growing interest in soils and the need to inform people about the importance of their country's natural resources, the Department for Environment, Food and Rural Affairs (Defra) commissioned Cranfield University's National Soil Resources Institute to develop a curriculum-linked website on soils for Primary and Secondary school-age children and their teachers. The resulting free Internet portal: <http://www.soil-net.com> is a comprehensive educational resource, aimed at Key Stages 1 to 4 concerning soils, their functions, and the challenging future that they face. It has an important *Introductory Section* including subjects like What Soil Is, How Soils Form, The



Properties of Soils, What Soils Can Be Used For, and Soils As A Living Being. There is a section dealing with the *Global Cycles*, these marvellous cycles, of which soil is just a part, which ensure that nitrogen, oxygen, carbon, water, and nutrients can be recycled time and time again to support future generations of plants, animals and human beings. There is a substantial section on *Soil Functions* which deals with all the uses that are made of soils and how important soils are in achieving these functions to support life on earth. There is a section on the *Soils of Britain and the Soils of the World*. The two other main sections deal with *Threats to World Soils* and *Concerns for the Future of Soils*. Soil-Net.com contains numerous case studies, features on school gardens, indoor and outdoor soil experiments, interactive soil maps, 3D soil walks and a host of other classroom-trialled teacher-support materials. To ensure the website comes vividly to life, Cranfield have partnered with the Norwich School of

Art and Design who have produced the excellent animation and graphics of the site. The Soil-Net.com website was formally launched at the 2007 ASE conference in Birmingham.

A recent initiative ‘SoilPIC’ aims to draw together and publish tens of thousands of photographic images of classified soil types and their representative landscapes, as well as a host of other land-related themes. The images will be placed into a public-facing ‘Wiki’ engine. Further details and imagery captured to date are at <http://www.wossac.com/photographs>. It is envisaged that this initiative can offer educational materials for a more senior audience where Soil-Net is aimed at schools.

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Hallett, S.H. (2007) "Of Earth and Water: Look under your feet", Environmental Education, 28.

Hallett, SH. & Bullock, P. (2007) "www.Soil-Net.com : A new educational website enabling young people to learn about soils. Article printed in the Association for Science Education, 'Education in Science' journal, number 221, February 2007."

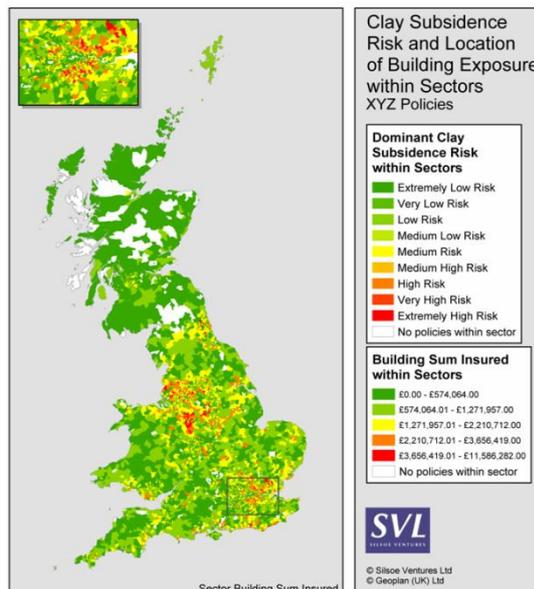
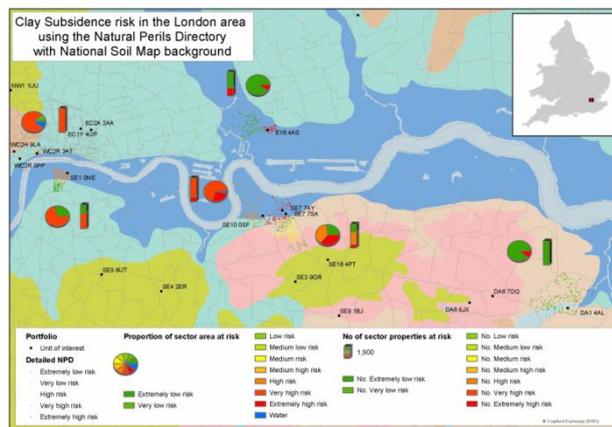
Soil-related Traditional and Digital Cartography

With over 60 years of expertise, NSRI's has a well-equipped cartographic unit which specialises in the production of both traditional and digital mapping, which has previously been recognised by the British Cartographic Society with the award of the prestigious John Bartholomew's Award for Excellence in Small-Scale Thematic Cartography.

NSRI offers a full range of capabilities using digital and traditional mapping techniques including:

- Digital and Traditional Map preparation;
- Geographical Information Systems (GIS) expertise;
- Data capture and processing;
- Graphical layout, design and production;
- Reprographic and photographic services to A0 size;
- Cartographical project management.
- Internet mapping capabilities.

NSRI's strength is the ability to use the latest GIS technologies alongside traditional cartographic principles to produce high quality mapped outputs. Below is a selection of NSRI's recent cartographical products.



Environmental Project Management

NSRI brings to its work a clear commitment and strong capability in project management techniques as well as the technical expertise the necessary scientific and Information System disciplines. The Cranfield team has a long-standing experience of working to IS Quality Assurance structured guidelines such as PRINCE. The PRINCE methodology has been successfully adopted as the governing structure for many of the example projects listed here, complementing equivalent experience with Unified Modelling Language (UML), Structured Systems Analysis and Design Methodology (SSADM) and other formal systems analysis methodologies.

Cranfield Awards

Cranfield University was awarded the Queen's Anniversary Prize for Higher and Further Education in 2005 and 2007.



Cranfield University has also been awarded the ISO 14001 environmental management system standard.



NSRI Project References

NSRI has considerable experience of conducting successful IS projects. Details of some of these projects are given below.

Land Information System - LandIS

The principal focus of NSRI's database design, development and management activities is the LandIS system. The UK Government continues to partly-fund maintenance and development of the system and, in return, data from LandIS are released to Government users, but leased to private sector users on a commercial basis. The LandIS databases contain a comprehensive range of information about the soils of the UK. The principal data sets are outlined below.

Part of the published National Soil Map at 1:250,000 scale, each grid square is 10 km x 10km

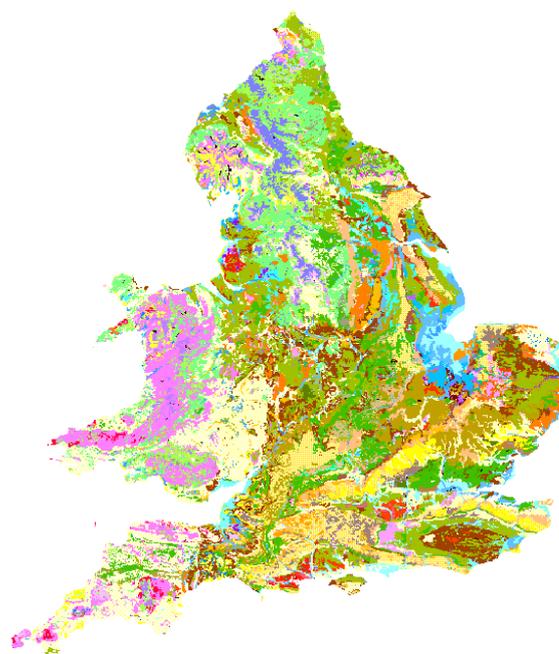
Map data

The National Soil Map describes the distribution of different soils of England and Wales and is available in digital form corresponding to different spatial resolutions. The published 1:250,000 scale National Soil Map delineates areas of similar soils down to a minimum area of about half a kilometre square

This information is also held digitally, either in raster (100m x 100m pixels), or in vector format as polygons with attached attributes that describe the contents of each polygon in terms of the percentage cover of each soil type present. Two simplified versions of the National Soil Map are also held in LandIS, with individual pixels representing 1km x 1km and 5km x 5km squares respectively.

Soil property data

The soil types used in the National Soil Map are called soil series. For each of the soil series present on the map, LandIS contains more than one hundred *soil series property data sets* which relate either to the whole soil or to one of the layers that comprise the soil profile.



Interpretation keys

A range of *interpretation keys* (for converting soil series into risk ratings such as Aquifer Vulnerability - Soil Leaching Class) to help identify the vulnerability of groundwater are also present in LandIS.

Inventory data

The *National Soil Inventory* is a group of data sets that relate to points on a 5 kilometre grid across England and Wales that were not in the centres of large conurbations. For each there is a complete soil and site description, and results from analysis of the inorganic composition of the topsoil.

The *NSI* is a snapshot of the soil kingdom in England and Wales initially from 1980 and now, through partial re-sampling, from more recent years.

Soil profile data

Records of soil profile descriptions and related soil physical and chemical analyses form a further component of LandIS as do short field descriptions of soil profiles.

The identified components are linked by a number of common attributes and these are identified in the following illustration.

The image shows a computer-compatible NSI recording card. It is a grid of fields for data entry, organized into sections for different soil profile horizons (A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z). Each field contains a small icon representing a data type or value. The card is designed for data entry into a computer system.

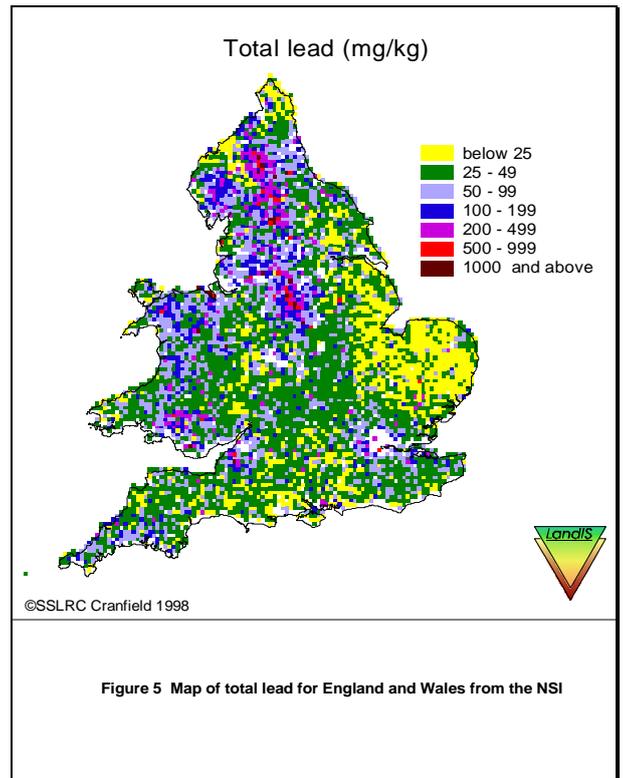


Figure 5 Map of total lead for England and Wales from the NSI

Computer-compatible NSI recording card

The components identified are linked by a number of common attributes and these are identified in the following table.

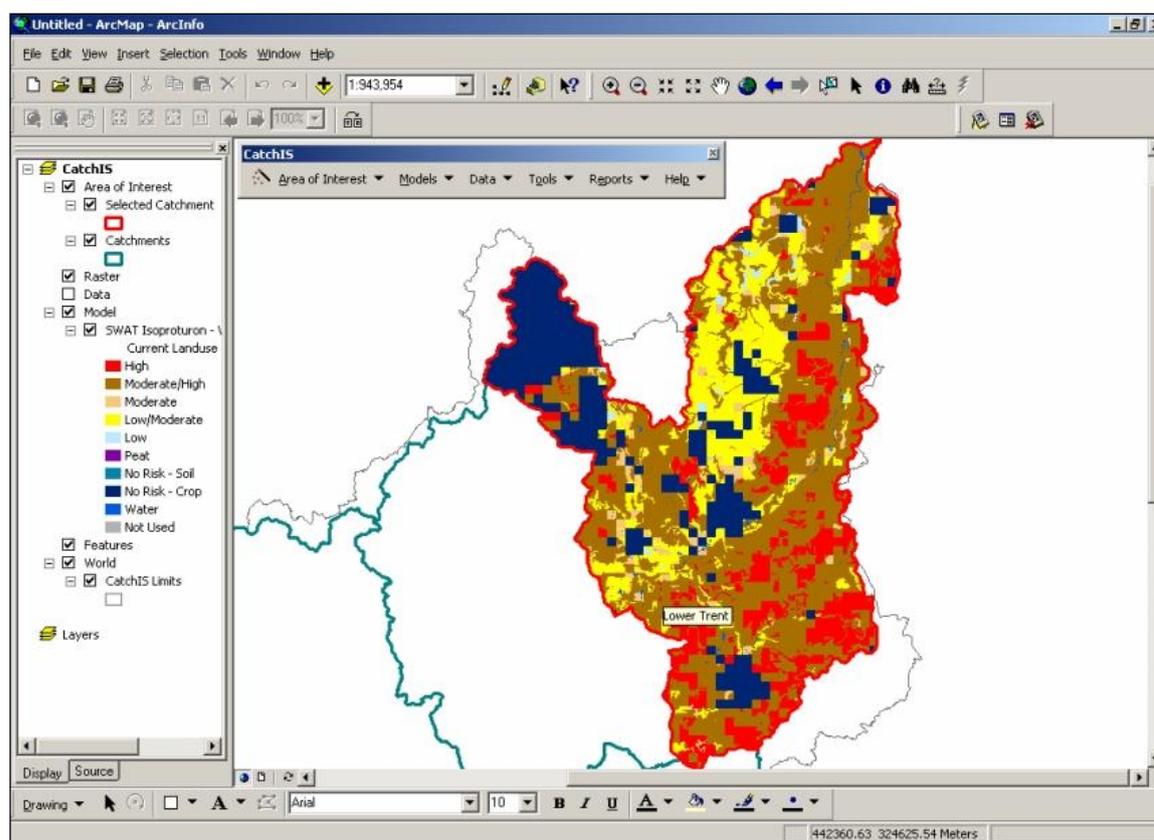
Common attributes for linking data groups, products and data sets	LandIS Product Groups				
	National Soil Map (PG 1)	Soil property data sets (PG 2)	National Soil Inventory (PG 3)	Soil type interpretations (PG 4)	Soil profile records (PG 5)
Grid reference	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
Soil type (major group through to soil series)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soil lithology (geological deposit or rock type)	<input type="checkbox"/>				<input type="checkbox"/>
Land use/cover	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
Altitude/slope			<input type="checkbox"/>		<input type="checkbox"/>

LandIS now has modelling functionality that makes use of logical data models to derive suitability and risk assessment information that can be presented in map form. The system has been used to inform decision-making in a range of land management contexts. The influence that soil has on so many environmental and ecological processes means that soil conditions impact on very many rural activities. The following lists of issues and activities, organised under broad headings, indicate past applications of LandIS and its data. NSRI has been involved in research and/or consultancy projects in all of the topics.

Environmental Information Systems

CatchIS

CatchIS, or Catchment Information System, (<http://www.catchis.com>) is a spatial decision support tool for managing the water resources within individual catchments for a number of water utilities, including Severn Trent Water Ltd., Yorkshire Water Ltd., United Utilities and Anglian Water Ltd.. CatchIS presents an overview of water resources, soil and climate, and encapsulates a number of models which address aquifer and surface water environmental vulnerability from diffuse contaminants. CatchIS was the joint winner of the prestigious 1994 Association of Geographic Information (AGI) Technical Progress Award. The system can be customised for other water supply companies and regulators.



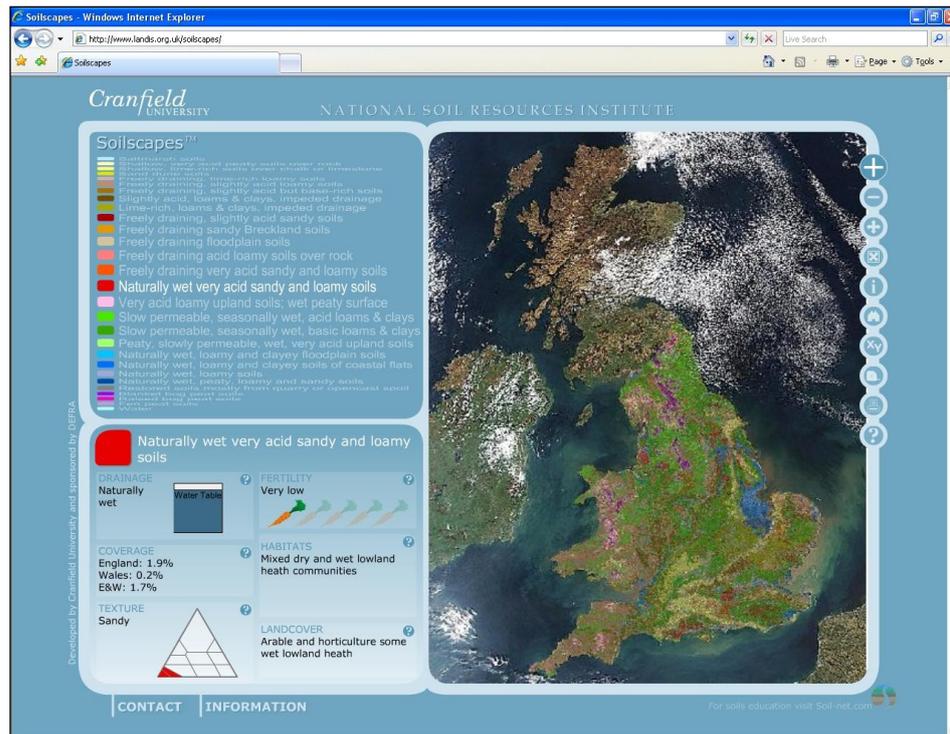
Example CatchIS output

Soilscapes viewer

The Soilscapes Viewer (<http://www.landis.org.uk>) is a free, easy-to-use, online soil reporting tool which produces summary soils information for a specific location, based upon the NSRI “Soilscapes” soil thematic dataset. Soilscapes Viewer provides a free-access search tool to reveal basic soils information for England and Wales at locations searched by Postcode. In addition to the soils, expressed using the simplified 24-class Soilscapes classification, the result also presents basic soil hydrological and fertility information in an easily accessible form.

Soilscapes is a 1:250,000 scale, simplified soils dataset covering England and Wales. It was created from the far more detailed National Soil Map (NATMAP Vector) held by NSRI at Cranfield University, with the purpose of communicating effectively a general understanding of the variations which occur between soil types, and how soils affect the environment and landscape of the two countries. Soil exerts a strong influence on our whole ecosystem, being the foundation for many of the ecosystem services and functions recognised, and is a fragile resource that needs to be understood and protected.

Soilscapes is one of the most popular datasets available from NSRI - and to encourage a wider understanding of soils, web access to this data is now made freely accessible. Soilscapes does away with confusing terminology, enabling informed decision-making by non-soil scientists who need to understand soil and how it affects broad landscapes. Using the Soilscapes viewer, it is simple to build up a good understand of many fundamental soil-landscape processes for any region across England and Wales.

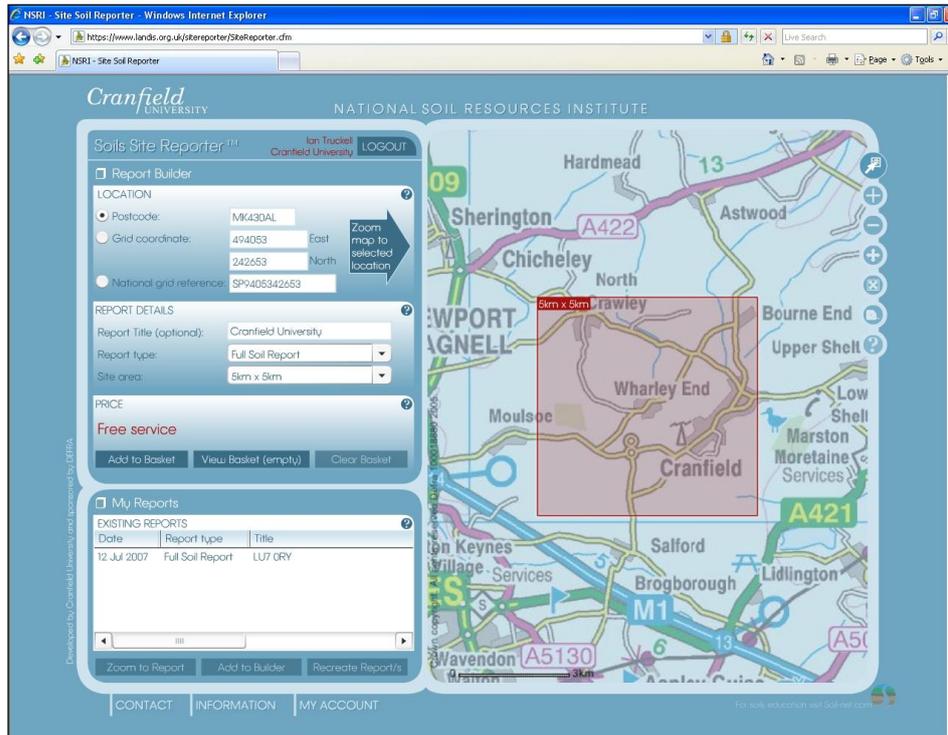


Soil Site Reporter

The Soil Site Reporter (<http://www.landis.org.uk>) offers an online service to clients to create comprehensive reports for locations in England and Wales, providing tailored information as to the site characteristics.

The Soils Site Reporter is an easy-to-use, online soil reporting tool which produces site-specific soils information with maps and soil descriptions. As the national authority on the sustainable management of soil resources for England and Wales, NSRI holds a vast collection of soils information, now available in a matter of minutes with the input of a grid reference or Postcode.

Each report, downloadable in pdf format, provides detailed information on the expected soil conditions at the site and outlines interpretations of the suitability for different uses. A variety of environmental issues such as the potential of damaging ground movement or pipe corrosion and the ease with which chemicals can leach into groundwater or run off into rivers are also included.



Those undertaking an environmental impact assessment (EIA) or a strategic environmental assessment (SEA) are required by EU law (85/337/EEC & 2001/42/EC) to identify, describe and assess the direct and indirect effects of a proposed project scheme on the soil environment (the ground) and its functions and composition, as well as and closely-related environmental themes (e.g. groundwater, flora, fauna, landscape).

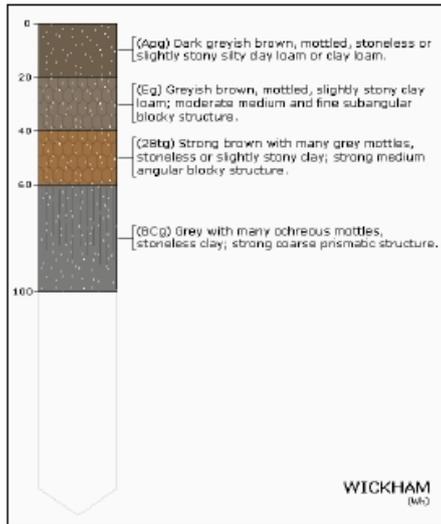
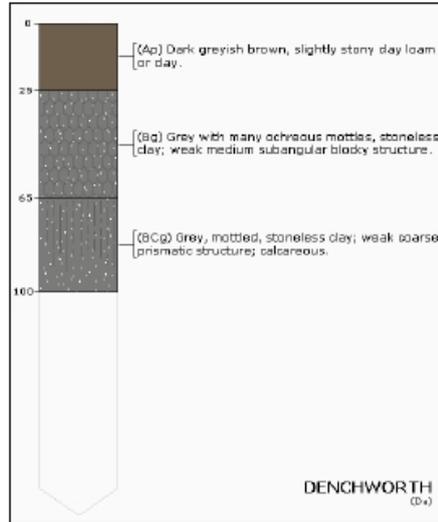
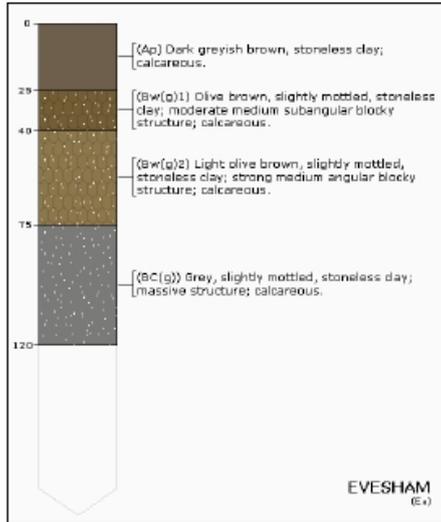
The Cranfield Soils Site Reporter provides an ideal preliminary reference source for these assessments as it identifies and describes the soils present around a site, and highlights potential issues which should be considered as part of these integrated assessments.

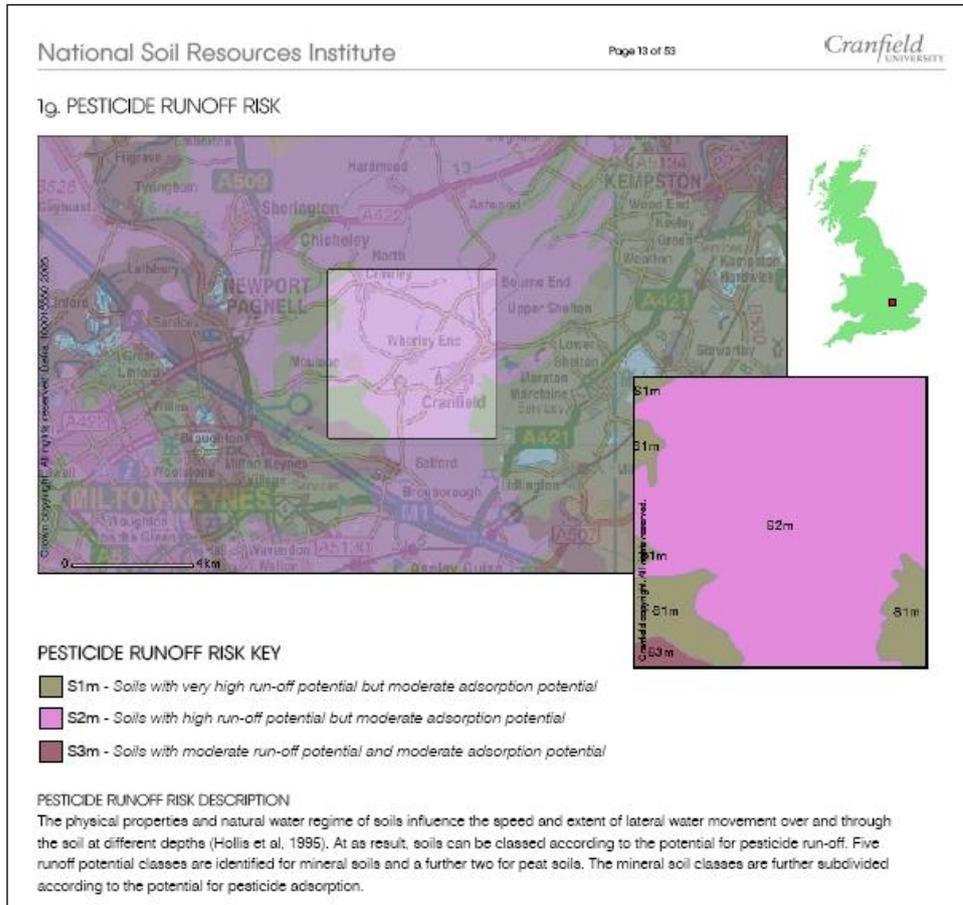
The report describes the interaction between soil and habitats, water movement, and the impact of soil on material assets and cultural heritage in the form of damaging ground movement and conditions. A description of the interaction between these factors is also required by EU legislation.

The inclusion of a Soils Site Report in an EIA or SEA will quickly enable an understanding of the key issues surrounding the soil “land bank” relating to a given project, as well as to provide pertinent information on a range of other issues including flood extent vulnerability, geo-hazards and background levels of soil contaminants.

EVESHAM 2 (411b)
Slowly permeable calcareous clayey soils.

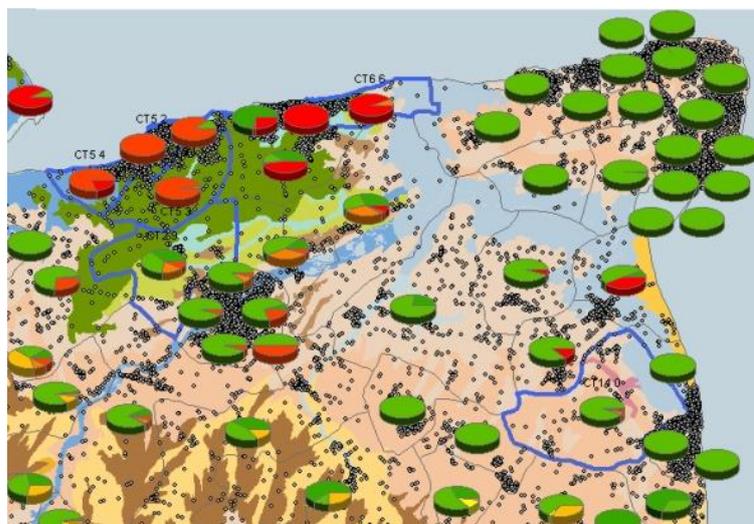
d. EVESHAM 2 Component Series Profiles





Natural Perils Directory (NPD)

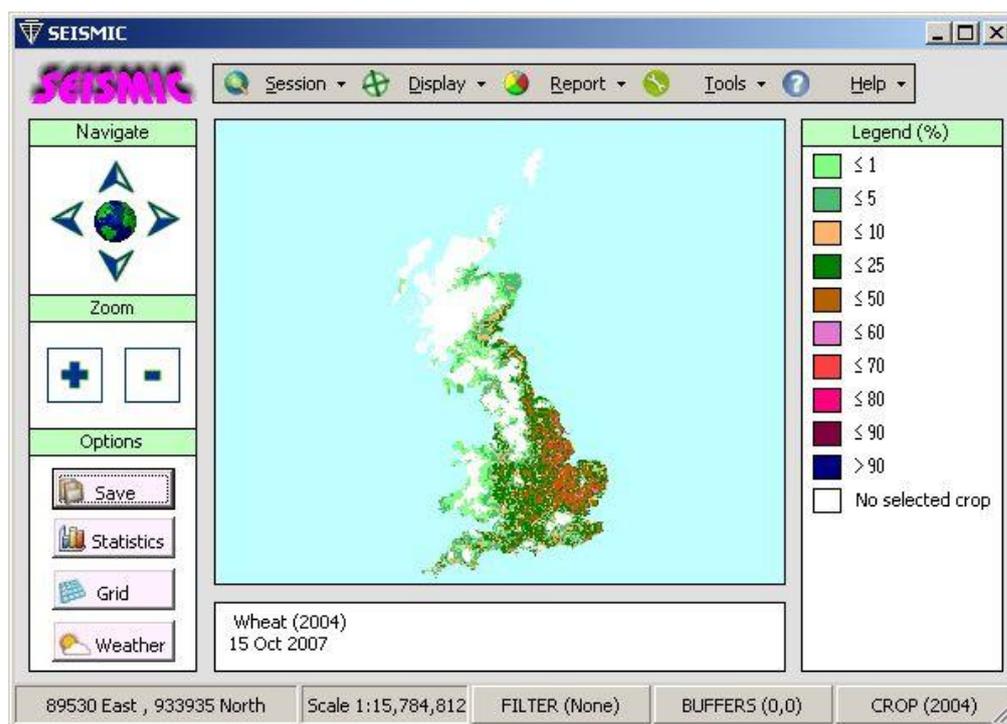
The Natural Perils Directory, or NPD is a risk prediction system designed for the insurance industry. It uses knowledge about the effects of climate on soils and predicts the risk of foundation subsidence, flooding and damage by wind. This system is in wide use within the UK finance sector.



Underground Foundation Vulnerability Model by Postcode District

Spatial Environmental Information System for Monitoring the Impact of Chemicals

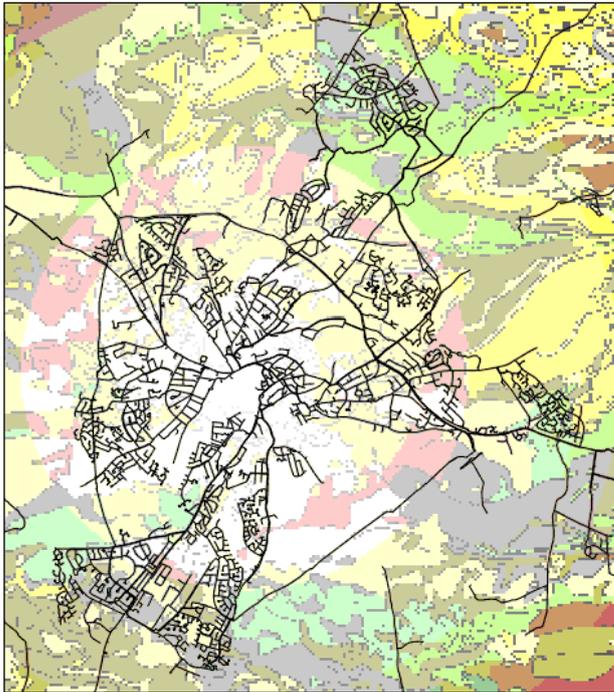
SEISMIC is a spatial environmental system, which provides the detailed data, required to model the impact of chemicals in the environment. It can be used to examine relationships between soil types, topsoil characteristics, cropping and climate patterns in England and Wales. It was developed in collaboration with the Ministry of Agriculture and Fisheries, UK and the British Agrochemicals Association. A Europe-wide version is now being prepared. This project exemplifies the bridge between Government and Industry, which NSRI has offered in many consultancies.



Pesticide Run-off Potential for land under crops

Leakage Assessment for Corrosivity and Shrinkage - LEACS

LEACS addresses the risk of ferrous metal corrosion, specifically the corrosion, fracture potential and failure of water supply mains. Output from this system has been used by several water supply companies in preparing and prioritising mains replacement and rehabilitation programmes. Clients include the UK water companies Bristol Water, Thames Water, Severn Trent Water, Southern Water, South West Water, Yorkshire Water and many of the smaller companies such as Mid-Kent Water, Portsmouth Water and Essex and Suffolk Water.



Example of Pipe Network interacting with the LEACS system

Predictive Models for Supporting Nitrate Policy

The main objective of this project (UK Ministry of Agriculture, Fisheries and Food: Project NT1701) was to develop a unified approach to the estimation of nitrate loadings to fresh waters from agricultural sources. The work had to address factors such as differences in land-use, fertiliser and manure usage, soil type and hydrology, climate, time-scale and geographical scale. The approach had to operate at the field, catchment and regional level.

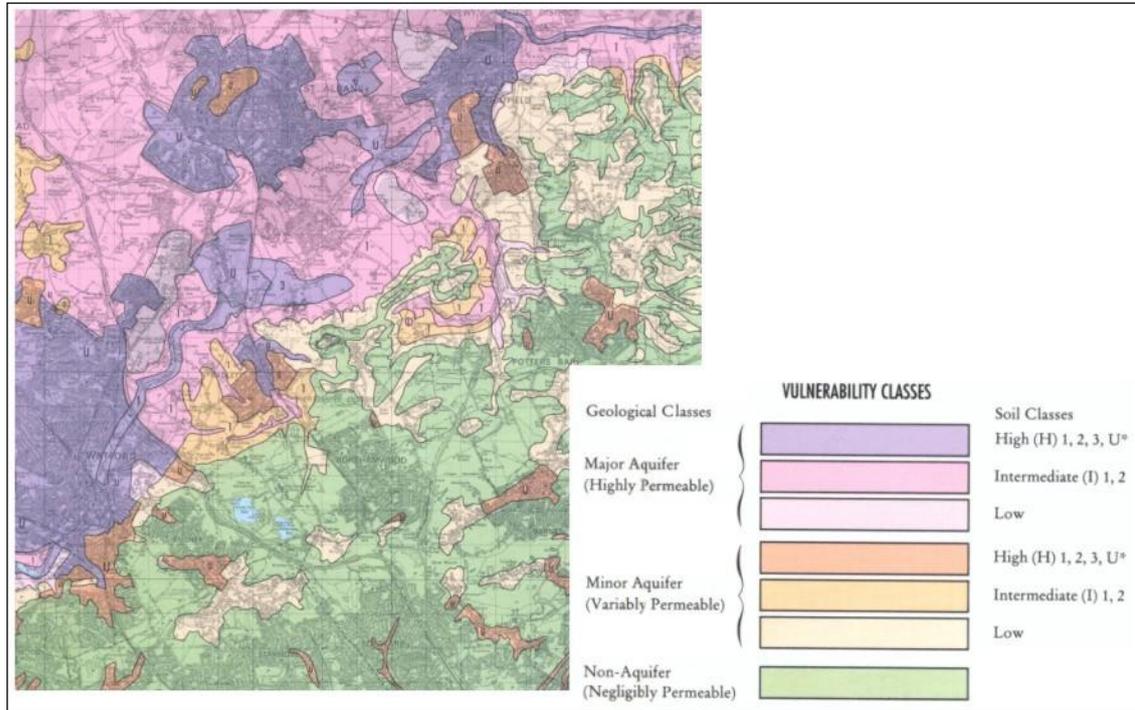
NSRI was chosen to participate in this project for its proven excellence in understanding the relationships between soil types as they influence soil-water-solute behaviour, the application of the HOST model (Hydrology of Soil Types) and its research into the effects of change in geographic and temporal scale on process based models.

Groundwater Vulnerability Assessment

Groundwater Vulnerability is a major element of the UK's groundwater protection strategy formulated as the Policy and Practice for the Protection of Groundwater by the Environment Agency (EA). The link between land use planning and groundwater protection is the national series of groundwater vulnerability maps published by the Environment Agency as an integral part of their Groundwater Protection Policy.

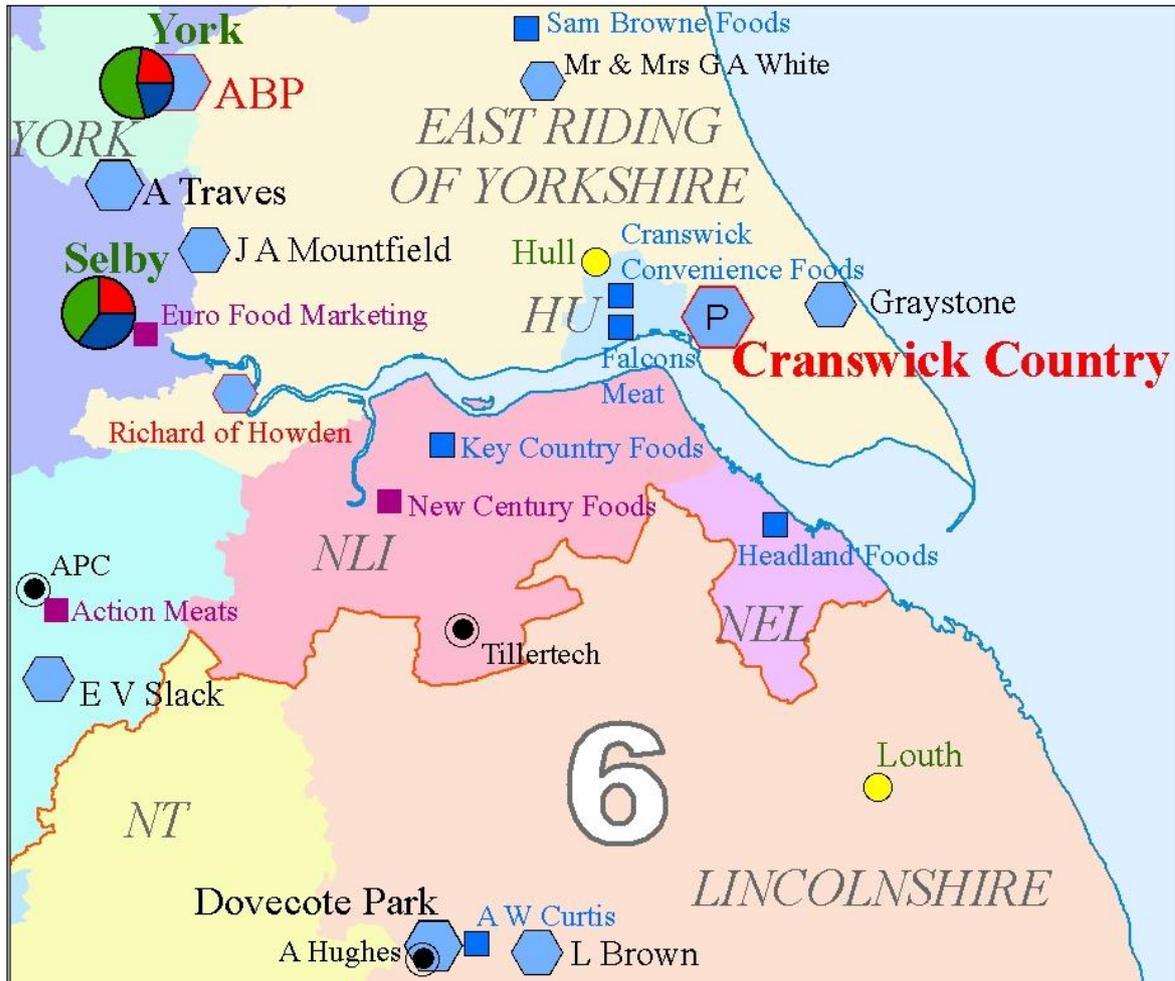
In England and Wales, 53 maps have been compiled by NSRI and published at 1:100,000 scale by the EA. These maps provide national coverage and are widely used in the statutory land use planning process. The maps are unique in the way they handle soil and hydrogeological information to indicate, in a simple visual manner, the degree by which soils and superficial deposits protect groundwater resources (aquifers) from diffuse source pollutants used on the ground surface. They allow better-informed judgements on the location of new developments. This helps to avoid placing potentially polluting activities in highly vulnerable areas whilst allowing a more permissive view to be taken in areas of low groundwater vulnerability.

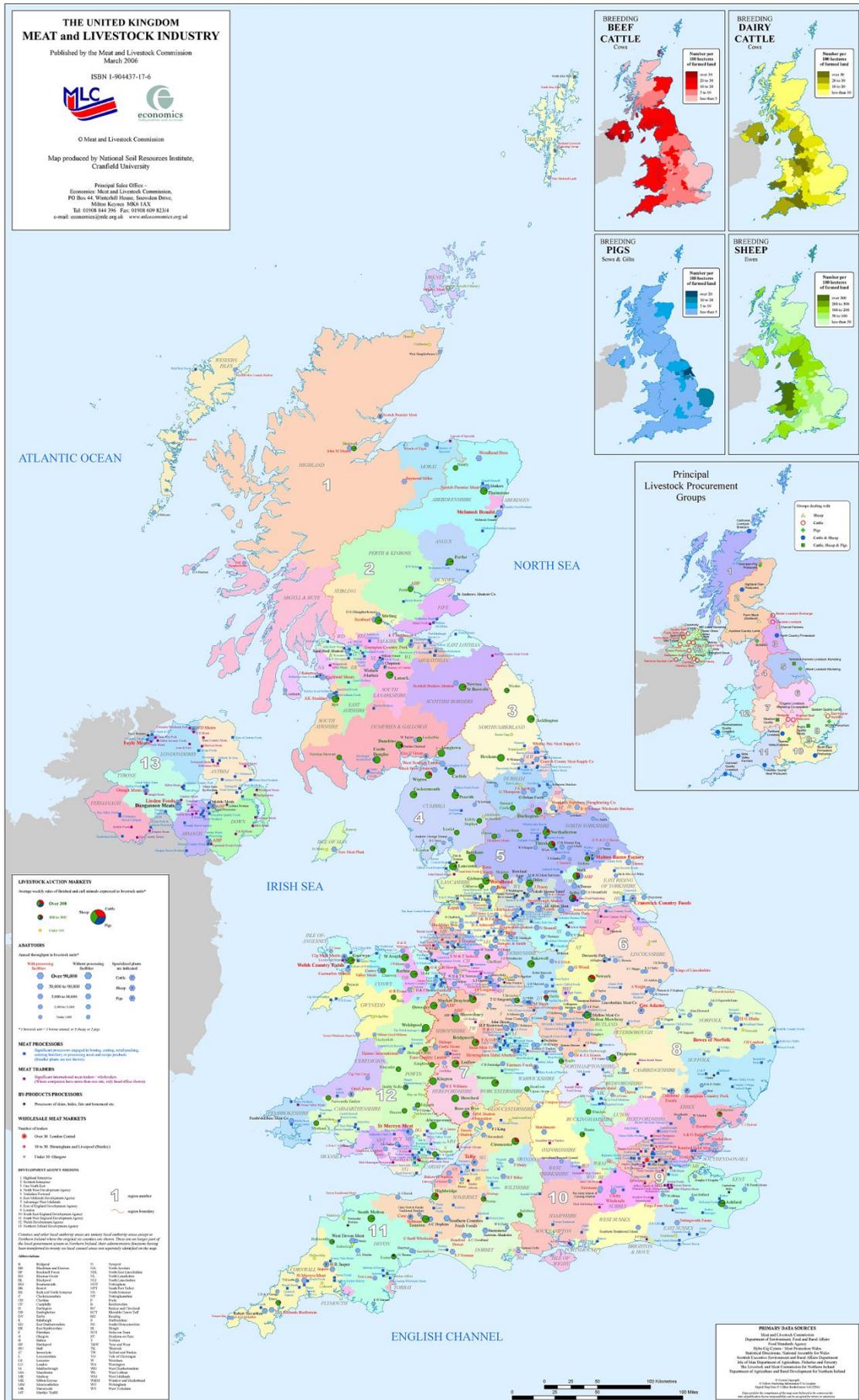
The groundwater vulnerability methodology devised by NSRI has been incorporated into the national groundwater protection policies of Scotland, Northern Ireland and the Isle of Man. The system has also been used with success in Eastern Europe (Lithuania) and in the tropics (The Philippines).



Meat Livestock Commission (MLC) Cartography

Cartographic work was conducted for the MLC to produce the mapping elements required for a commercial print run of mapping of the location of various processing and rendering facilities across England and Wales. These maps are regularly updated and typify the quality of cartographic capability offered by NSRI.





International Project References

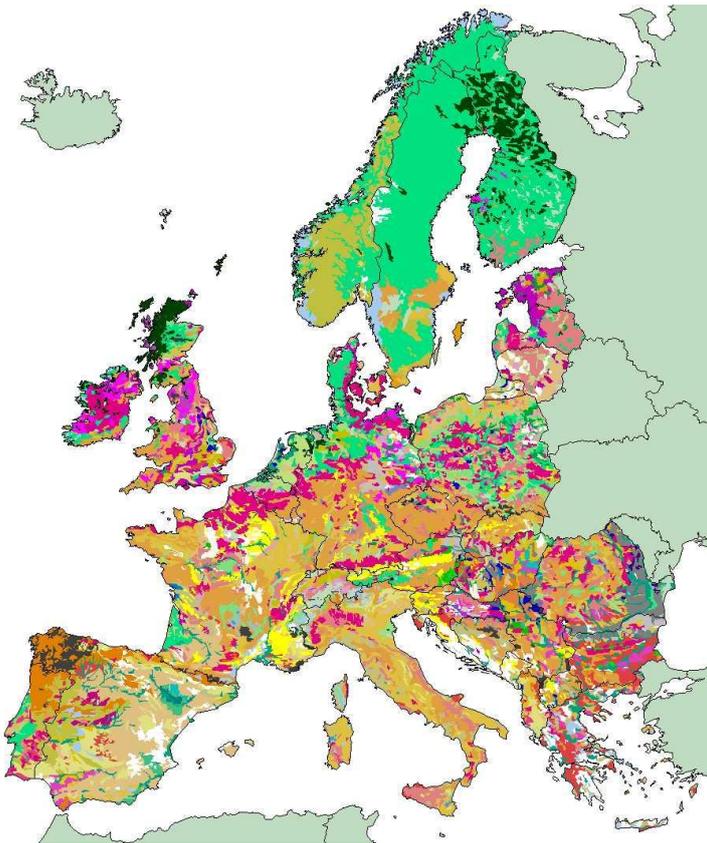
There follows a selection of representative international project references for work NSRI has conducted overseas. These projects typify the capabilities offered by NSRI.

Project: The European Soil Database

Client: Joint Research Centre, Ispra Italy

Funding: European Union

A Soil Map of the EC was produced at 1:1,000,000 scale in the 1970s through the collaboration of a network of academic soil scientists. The map was digitised and the soil types subsequently harmonised according to a standard soil classification (FAO 1974). It was later expanded to include the 15 EU member states, the former EFTA countries (Norway, Switzerland and Iceland) and the countries of Eastern Europe. The development of the European Soil Database has been co-ordinated in the main by the European Soil Bureau (ESB), located at the Joint Research Centre (JRC), Ispra (I). The European Soil Bureau was created in 1996 as a network of national soil science institutions. Its main tasks are to collect, harmonise, organise and distribute soil information for Europe. The activities of the ESB are, and have always been, driven essentially by the demands for soil information by the EU Member States and the European Commission. NSRI has played a key role throughout development of the European Soil Database.



Soil Map of Europe at 1:1,000,000 scale

Currently, the ESB is providing soil information to the Commission for tackling a number of problems including: desertification, particularly soil erosion, salinisation, and structural disintegration, in the Mediterranean Basin; disposal of sewage sludge – the current EC directive on the use of sewage sludge in agriculture is in the process of revision; pollutant

transfer (agrochemicals – fertilisers, pesticides and herbicides); loss of organic matter; subsoil compaction; water supply.

Project: Irish Soil Information System (ISIS)

Client: Irish Environmental Protection Agency

Funding: STRIVE programme

The demise of the former national Soil Survey in Ireland left a serious data deficit in the Irish soils thematic area, needed to support and underpin a raft of policy and operational environmental decision making. The ISIS project has been funded by the Irish Environmental Protection Agency (EPA) to seek to address this issue through the application of modern digital soil mapping techniques deployed in tandem with traditional field survey techniques for sampling and validation.



The project is run by Teagasc, the Irish agriculture and food development authority, with Cranfield University staff acting as technical consultants. The work will involve a range of activities to build up the Irish soils information base. The final products will provide a strengthened Irish national response to emergent policy and legislative developments in the environmental area.

The key objectives of ISIS include:

- Rationalisation, Harmonisation and Correlation of Irish soil types;
- Digital soil mapping and predictive mapping techniques;
- Field Validation & Sampling Campaign;
- Final Map Development and Publication Preparation;
- Development of a Soil Information System.

Project: e-SOTER – Soils and Terrain Database

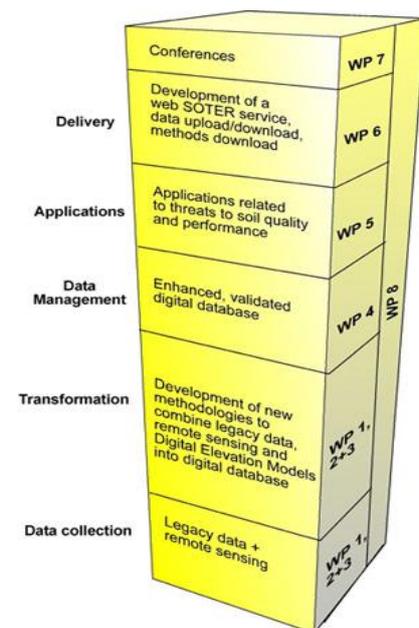
Client: European Union

Funding: Framework 7 Programme

The e-SOTER project (<http://www.esoter.org>), funded by the EU Seventh Framework programme, is set to represent the European contribution to ‘GEOSS’, the Global Earth Observing System. It is led by ‘ISRIC – World Soil Information’, with a consortium of 14 partner institutions. SOTER (SOil and TERRain) offers a practical methodology to provide information for a wide range of applications such as crop suitability, soil degradation, forest productivity, global soil change, irrigation suitability, agro-ecological zonation, and risk of drought. The GEOSS project plans a Global Earth Observation System and, within this framework, the e-SOTER project addresses the requirement for a global soil and terrain database. As the European contribution to a Global Soil Observing System, it will deliver a web-based regional pilot platform with data, methodology, and applications, using remote sensing to validate, augment and extend existing data.

The e-SOTER project will deliver a Pilot Platform and an Internet portal that provides open access to:

- a methodology to create 1:1 million-scale SOTER



databases, and an enhanced soil and terrain database at a scale of 1:1 million for the four pilot windows;

- an artefact-free 90m DEM;
- methodologies to create 1:250,000-scale enhanced SOTER databases, and the databases themselves for four pilots;
- advanced remote sensing techniques to obtain soil attribute data;
- validation and uncertainty propagation analysis;
- dedicated applications related to major threats to soil quality and performance.

Project: European Soil Data Centre (ESDaC) Consortium

Client: European Union

Funding: European Union

Cranfield University leads a consortium of expert institutions across the EU, working to address the soil-related requirements of the European Joint Research Centre (JRC) (<http://www.esdac-consortium.eu/>). The work involves interpreting requests accurately into well-defined briefs and forming teams of leading experts, backed by supporting resources including access to data, and then managing delivery of a series of studies to achieve:



- a high technical standard that can be confirmed by peer review;
- excellent timings;
- willingness to respond flexibly to new perspectives;
- awareness of the need for confidentiality;
- the highest quality of document presentation.

The consortium's work is dedicated to broadening and developing the knowledge base of the European Soil Data Centre, or ESDaC, by providing information and related policy documents being:

- original or value-added - informed by a comprehensive and up-to-date knowledge of soil and related sciences drawn from cutting-edge research;
- timely - in terms of responsiveness to urgent requests and meeting tight deadlines;
- policy relevant - framed and focused to clearly and concisely answer questions posed by policy-lead officials;
- trans-national in perspective - with a European level viewing point.

Project: The Impacts of Potential Climate Change on European Land Use

Client: European Union

Funding: European Union

NSRI was the lead agency in this project, completed in July 1999, to model the impacts of potential climate change on land use within Europe. The principal objective was to develop an "expert system" to predict the effects of a climate change on the cropping potential of areas of land based on knowledge of their known soil pattern, the properties of these soils and the growth requirements of strategic crops.

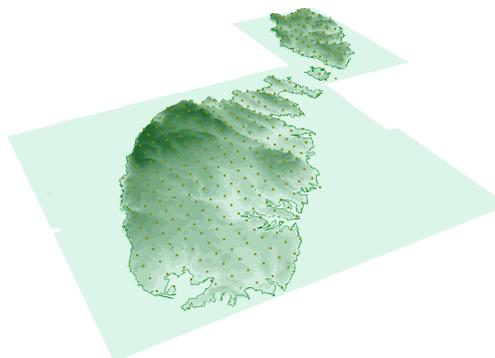
NSRI provided the project management and key specialist expertise for the participating organisations: Institute of Agrophysics of the Polish Academy of Science; Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (RISSAC); and Research Institute of Soil Science and Agrochemistry, Romania (RISSA)

Project: Impact Assessment Study of Malta's compliance with the EC 'Nitrate in Agriculture' Directive prior to Malta's accession to the European Union in 2003

Client: Government of Malta

Funding: Government of Malta

EC Directive 91/676/EEC concerns the protection of waters against pollution by nitrates from agricultural sources. Monitoring of Malta's surface and groundwater has identified nitrate concentrations above permitted levels, but there is no information on the relationship between agricultural practice and the nitrate concentrations found in these waters.



The Maltese Government required an assessment of the measures necessary to achieve compliance with the Directive by 2003, including the establishment of human and other resources and an outline of the time frame and costs. The NSRI project study details the obligations and deadlines, collates and reviews available information about the nitrate concentrations, identifies gaps in information, expertise and resources and recommends means by which these may be filled. It proposes a staged programme of required actions and investments within the public sector with estimated costs, and consults throughout the procedure with the European Commission. It also estimates the eventual agronomic and financial impact of compliance with this directive on the agricultural community.

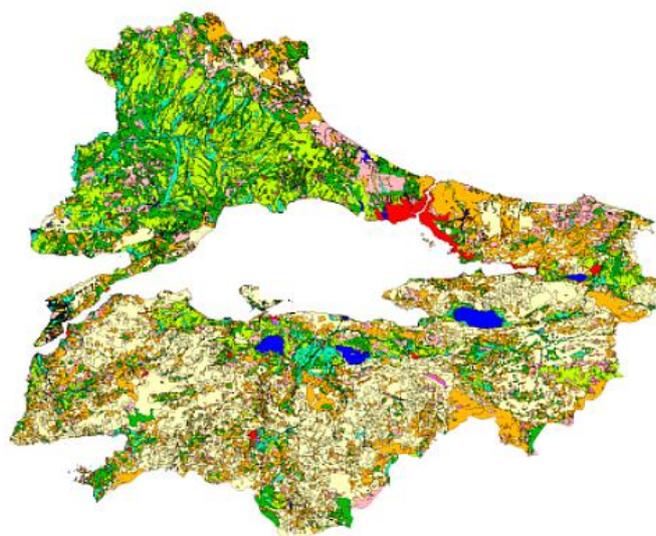
Project: Development and Feasibility of the Turkish National Soil and Water Information System

Client: General Directorate of Rural Services, Ankara

Funding: Government of Turkey

Turkey has a total land area of 78 million ha. With some 28 million ha devoted to cultivation. The soil resources of Turkey have therefore received particular attention for land use planning and the sustainable management of natural resources. This is the responsibility of the Turkish Ministry, the General Directorate of Rural Services (GDRS).

The Soil and Water Resources National Information Centre was established by GDRS to create the database of national soil and water resources and to use Geographic Information Systems (GIS) and Remote Sensing (RS) techniques in planning and analyzing natural resources and to provide speed and flexibility to the users and decision makers.



NSRI was commissioned by GDRS to conduct a feasibility and scoping study for the newly formed Soil and Water Resources National Information Centre (NIC). The Centre was conceived to provide a national on-line data resource for the Regional and

Provincial Directorates, Research Institutes and associated support organisations within GDRS.

NSRI consultants worked with the GDRS team to undertake an audit of existing resources: staff, hardware, software, network and data. This information was used in evaluating the feasibility of a number of technical and management solutions. Specifications were prepared for the implementation stages of the GIS framework including all aspects of hardware, software, data capture and management and user applications, as well as team structure and training.

Project: Development and Implementation of a Computerised Soil Information System

Client: Government of Bangladesh

Funding: Government of Bangladesh and Danida (Danish Aid Agency)

This project to provide specialist advice on the development and implementation of a computerised soil information system for the Soil Resource Development Institute (SRDI) in Dhaka, Bangladesh was undertaken from 1996 to 1999. The work was under a sub-contract to Kampsax International of Copenhagen. The project involved the training of SRDI staff at NSRI in computer information systems and the application of these systems to soil surveying and land use planning as well as four, four week visits of an NSRI GIS and modelling expert to Bangladesh. Consultancy services included assistance in the acquisition of hardware, the setting up of the systems, advice on the work programme and applications of the system as well as a review procedures and quality.

Project: Development and Feasibility of the Pakistan Land Information System

Client: Soil Survey of Pakistan

Funding: Euroconsult, The Netherlands

The Pakistan Land Information System (PAKLIS) was created for the Soil Survey of Pakistan (SSP) between 1996 and 1998. The country is prone to flooding and subsequent soil erosion, and the government required information on land use, crop management and catchment management in an accessible electronic form. NSRI implemented a phased approach: Phase 1 involved setting up a PC-based system for data capture included the construction of a metadatabase and a database management system, and software to handle satellite image processing; this was expanded in Phase 2 by connection to powerful Unix servers for graphics processing and database work.

Project: Jordan Soil and Climatic Information System

Client: Government of Jordan

Funding: European Union

In 1989 the Jordanian Government initiated the Jordan Soil and Climatic Information System (JOSCIS) as part of an initiative by the European Union to fund development projects in neighbouring countries, particularly in the Mediterranean. NSRI was responsible for the development of JOSCIS that was completed in 1994. More than 30,000 inspection pits were excavated and the basic soil properties recorded in computer compatible format. Samples from more than 300 soil profiles were taken, analysed and the results and stored electronically. This makes JOSCIS one of the largest computerised information systems database outside the USA or the European Union. The system comprises modules for capture, validation, storage, retrieval and maintenance of soil and climate data. The system is PC-based and contains over 80 maps stored in digital form, covering geology, hydrology, vegetation, landforms, rainfall, temperature, mineral resources and crops. Working within tight political, budgetary and personnel constraints, NSRI was able to tailor this large-capability system to function on 3 PC workstations and 3 data-entry machines.

Project: Middle East Regional Dryland Information System

Client: Government of Jordan, Israel, Egypt and the Palestinian Authority

Funding: DANIDA

An NSRI representative was recently invited to Amman, Jordan, to lead a three-day conference involving delegates from the Governments of Jordan, Egypt, Israel and the Palestinian Authority (PA). The role was to act as co-ordinator for a ground breaking new initiative to create a Middle East regional soil and water information system. The intention of the project was to develop a trans-national information resource to address the topical issues of agricultural development in these semi-arid countries. Contemporary techniques employed in dryland agriculture, such as water harvesting, draw upon centuries of experience of the Bedouin and other native people. The challenge today, with ever-increasing pressures upon the area's scarce water resources, is to bring together the information needed to ensure that optimal and sustained use is made of these resources in meeting such demands. Cranfield was able to call upon over 30 years of experience in developing and implementing agricultural information systems, both in the UK and internationally, and over the next three years will play a key advisory and training role in the establishment of this initiative.

Project: Tanzanian Natural Resources Information System (TANRIS)

Client: Institute of Resource Assessment at the University of Dar es Salaam, Tanzania

Funding: World Bank

The Tanzanian Resource Information System (TANRIS) was initiated by the Institute of Resource Assessment at the University of Dar es Salaam to identify the extent and condition of natural resources for sustainable utilisation. TANRIS was set up between 1994 and 1998, to help combat severe environmental degradation taking place in Tanzania.

The Director of the Institute of Resource Management, the Project Leader and 2 staff members came to NSRI throughout the project to train in GIS, database administration and modelling. The NSRI Land Resource Manager and Head of Information Systems visited Tanzania, and 2 NSRI IT staff members spent several periods of 3 months and one of a year on site in Dar es Salaam, co-ordinating the design and setting up of the system, writing the software and integrating newly-trained members into the team. At the end of the project, in July 1998, NSRI had created a self-sustaining information system for environmentally sound management and development of land resources.

Project: Indian Land Resource Survey and Planning Centre Mission

Client: National Bureau for Soil Survey and Land Use Planning, India

Funding: Overseas Development Agency of UK Government

This project was commissioned by the 1988-92 linkage between the Overseas Development Natural Resources Institute (ODNRI) and National Bureau for Soil Survey and Land Use Planning (NBSSLUP). The objective was to assist with the establishment of an international-level training centre in land resource survey and planning. NSRI staff advised on:

- Methods and organisation of NBSSLUP, with particular reference to strengthening the training programme in soil survey techniques;
- Establishment of a computer-based information system and data management system.

In addition, thirteen staff members from NBSSLUP visited NSRI for training in computer information systems, cartographic techniques and land use planning.

Project: National Soil Service Project, Ethiopia

Client: Ministry of Agriculture, Democratic Republic of Ethiopia

Funding: Food and Agriculture Organisation (FAO) of the United Nations for the UN Development Programme (UNDP)

This project was managed by FAO and funded under the wider programme of UNDP in Africa. It was set up in 1988 following the serious famines that occurred in Ethiopia in the early 1980s. The objective was to develop a Soil Information System for Ethiopia (SISE) to support decision-makers in the Ministry of Agriculture concerned with food security. NSRI provided expertise for the specification, design and implementation of a pilot soil information system for the storage, analysis and retrieval of data collected by the National Soil Service Project.

NSRI Client List

The following presents a selection of the clients for whom NSRI have worked:

Agrochemical/Chemical sector

AgrEvo UK Ltd
Agrisearch
BASF
Bayer AG
Ciba Geigy
Corning Hazleton
Dow Agrosiences
Dow Elanco
Huntingdon Life Science
Monsanto
Rhone-Poulenc
Ricerca Inc

Utilities

Essex & Suffolk Water
London Electricity
National Grid
Severn Trent Water
Southern Water
Thames Water Utilities
Yorkshire Water
Southern Water
South West Water
United Utilities
Northumbrian Water

Other private sector

JMP Consultants Ltd
Kampsax International
Lloyds Aviation
Uniroyal
Equipax plc
ADAS Ltd.

Public Sector, Policy

Department of the Environment, Transport and the Regions
Department of the Environment, Food, and Rural Affairs
Environment Agency

European Commission
European Environment Agency
European Union
Isle of Man Government
Meteorological Office
Teesside Development Corporation
United Nations Environment Programme

Public Sector, Research

Central Science Laboratory
Economic and Social Research Council
Farming and Rural Conservation Agency (Defra)
Home Grown Cereals Authority
Institute of Grassland and Environmental Research
Department of the Environment, Food, and Rural Affairs
Meteorological Research Unit
Natural Environment Research Council – Institute of Terrestrial Ecology
Natural Environment Research Council – Centre for Ecology and Hydrology
EA Technology

Links and Operations in Europe

NSRI has strong links with institutes in most countries of the European Union and has a number of ongoing collaborative research programmes with the European Commission, the European Union and the European Environment Agency. The Institute has worked closely with the soil surveys and soil data centres in the EU for the past 20 years in the development of a harmonised soil database for Europe (see detailed description above). This database now contains information on Neighbouring and Accession countries as well as for the Member States. One of NSRI's experts was seconded to work in the European Soil Bureau based the EU's Joint Research Centre in Ispra, Italy, from 1998 to 2000.

NSRI co-ordinated an EU Framework Research Project (Euro 1.5 million) on nitrate modelling and monitoring. This involved 9 institutes in 5 countries and the results have been published by the European Commission as a Soil and Groundwater Research Report. NSRI is also the UK National Reference Centre for Soil, in the network of environmental centres co-ordinated by the European Environment Agency.

NSRI overseas

In addition to the work described in the International Project references, NSRI has also forged links with other institutes and undertaken collaborative research and consultancy assignments in Eastern Europe, Middle East, the Levant, Africa, Asia, South and North America.

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For more information or to find out more about NSRI, please visit our websites:

<http://www.landis.org.uk>
<http://www.cranfield.ac.uk/sas/nsri>
<http://www.wossac.com>
<http://www.soil-net.com>
<http://www.catchis.com>
<http://www.soilsworldwide.net>