The Contaminated Land Rehabilitation Network For Environmental Technologies in Europe

Final Report for Research Contract CLL 35/1/12: Managing and Developing the UK Interface with CLARINET

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for

The Department for Environment, Food and Rural Affairs

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Statement of use
This report summarises the findings of research carried out for the information review for project CLL35/1/12. The information within this document is for use by Defra staff and others considering the wider environmental value when remediating contaminated areas of land.

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Executive Summary

CLARINET, the Contaminated Land Rehabilitation Network For Environmental Technologies in Europe was a Concerted Action of the European Commission's Environment and Climate Research and Development Programme. The project ran from 1998 to 2002. It's primary objectives were to develop technical recommendations for sound decision making on the rehabilitation of contaminated sites in Europe and to identify research and development needs, in particular in relation to the recent EC Fifth Framework Programme (FW5).

CLARINET has been a successful EC project that has drawn on scientists and other experts from 16 countries in Europe to advance the state of the art in contaminated land management. A wide range of publications have been produced, which are available on it's web site (*www.clarinet.at*), including:

- Its overall findings: "Sustainable Management of, Contaminated Land: an Overview".
- Working Groups reports
    - Brownfields and Redevelopment of Urban Areas (WG1)
    - Review of Decision Support Tools for Contaminated Land Management and their use in Europe (WG2)
    - Contaminated Land and its Impact on Water Resources (WG3)
    - An Analysis of National and EU RTD Programmes related to sustainable Land and Groundwater Management (WG4)
    - Remediation of Contaminated Land. Technology Implementation in Europe -
    - State-of-the-Art (WG7)

In addition, CLARINET stimulated a number of "Satellite" Publications:

- Proceedings of the CLARINET Workshop on Ecological Risk Assessment, April 17-19, 2001 Nunspeet, The Netherlands. S-TEC 2001
- Environment Agency for England and Wales, June 2001: Epidemiology Workshop on Human Health Tools and Techniques - Report; Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4DU
- *Land Contamination & Reclamation*, Special Issue Vol. Nine - Number One, 2001; published by EPP Publications, 52 Kings Road, Richmond, Surrey TW10 6EP, UK
- Frank Swartjes, 2002: Variation in calculated human exposure: Comparison of
- calculations with seven European human exposure models (in press) - RIVM
- report 711701030; Amsterdam 2002.

CLARINET developed the concept of *Risk Based Land Management (RBLM)* as a step forward towards an integration of sustainable soil quality, protection of water and land use management in environmental policy. The aim of the RBLM is to achieve the integration of approaches originating from different perspectives (for example spatial planning, environmental protection and engineering), based on the identification of common goals:

- Comparable levels of protection of health and the environment, taking into account local characteristics;
- Optimised use and development of technical and administrative solutions; and
- Sustainability - evaluating and optimising environmental, economic and social factors

The concept applies at different scales – site, regional, national – and covers the whole cycle of risk assessment and risk management of contaminated land. It is driven by current and emerging scientific knowledge. It links to wider themes, in particular to soil protection, spatial planning, and water catchment management.

The concept also applies at a strategic level. However, it has practical application at a site specific level: the operational details of treatment, monitoring, aftercare and other risk management techniques (containment techniques for instance) can be assessed using the RBLM concept on a site-specific basis.

The UK, through DEFRA and the Environment Agency, has been a major supporter of CLARINET. In particular the UK participated in CLARINET through:

- a national ("country") representative;
- two scientific representatives;
- support for UK experts to take part in CLARINET working groups; and
- providing access to CLARINET for other interested parties throughout the UK.

Through this support the UK has been influential in CLARINET's many successes, in particular that CLARINET played a major role in delivering consensus across Europe on risk-based land management related to land-use. This consensus has been able to influence important new EC legislation relating to environmental liabilities and has been helpful in marshalling opinion against generic standards for groundwater quality in the Groundwater Daughter Directive. This support has also assisted the participation of a number of UK organisations in FP5 projects.

CLARINET's own conclusions were centred on Risk Based Land Management. CLARINET concluded that to put the RBLM concept into practice, action needs to take place on three main fronts:

- in continued research to improve the knowledge base and develop tools to support the emerging areas of European policy which are affected by contaminated land;
- in improving practice by the transfer of knowledge and information to a range of groups; and
- in integration of policy approaches.

The RBLM concept and its relevance for sustainable management of soil and water resources are currently being discussed at a European and - in some cases – national level, for example, by the Common Forum and with regard to future EU regulations, such as the Water Framework Directive and possible "Daughter-Directive" on groundwater, the EU Soil Policy, the Environmental Liability Directive and FP6. CLARINET's vision is to see a change in social and political attitudes away from a negative perception of contaminated land towards that of positive shared action to conserve and enhance the soil and water resources.

Contents

Glossary

Brownfields	Brownfield sites: • have been affected by the former uses of the site and surrounding land • are derelict or underused • have real or perceived contamination problems • are mainly in developed urban areas • require intervention to bring them back to beneficial use
cost benefit analysis	A form of economic analysis in which costs and benefits are converted into values for comparison
Concerted Action	An EC funding mechanism that supports networking activities
Decision Support	'the assistance for, and substantiation and corroboration of, an act or result of deciding'.
Decision support tool	An instrument which supports one or more components of decision making
Fifth and Sixth Framework Programmes	The EU's framework programmes for Research and Technological Development are major tools to support the creation of the European Research Area.
Groundwater	The mass of water in the ground below the water table (saturated zone) occupying the total pore space in the rock and moving slowly down the hydraulic gradient where permeability allows.
Multicriteria Analysis	A structured system for ranking alternatives and making selections and decisions.
NATO/CCMS Pilot Study	Within NATO the Committee on the Challenges of Modern Society (CCMS) supports a number of "Pilot Studies" for the promotion of technical exchanges on environmental issues.
Remediation	(a) The doing of anything for the purpose of assessing the condition of- (i) the contaminated land in question; (ii) any controlled waters affected by that land; or (iii) any land adjoining or adjacent to that land; (b) the doing of any works, the carrying out of any operations or the taking of any steps in relation to any such land or waters for the purpose-(i) of preventing or minimising, or remedying or mitigating the effects of, any significant harm, or any pollution of controlled waters, by reason of which the contaminated land is such land; or (ii) of restoring the land or waters to their former state; or (c) the making of subsequent inspections from time to time for the purpose of keeping under review the condition of the land or waters.
Risk Assessment	The process of assessing the hazards and risks associated with a particular site or group of sites.
Risk Management:	The process whereby decisions are made to accept a known or assessed risk and/or the implementation of action to reduce the

	consequences or probabilities of occurrence.
Risk Based Land Management	Risk Based Land Management is primarily a framework for the integration of two key decisions for remediation of contaminated land (1) the time frame: this requires an assessment of risks and priorities, but also the consideration of the longer term effects of particular choices, and (2) the choice of solution: this requires an assessment of overall benefits, costs and environmental side effects, value and circumstances of the land, community views and other issues.
Sustainable Development:	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Working Group	A topic related discussion group within CLARINET

List of Abbreviations

CBA	cost benefit analysis
CLARINET	The Contaminated Land Rehabilitation Network For Environmental Technologies in Europe
DEFRA	Department for Environment, Food and Rural Affairs
DST	Decision Support Tool
EC	European Commission
20-40 Euros/t	20-40 Euros/tonne
FW5 / FP5	Fifth Framework Programme / Framework 5 Programme
FW6 / FP6	Sixth Framework Programme / Framework 6 Programme
MCA	Multicriteria Analysis
NATO/CCMS	NATO Committee for Challenges to Modern Society
r3	r^3 environmental technology ltd
RBLM	Risk Based Land Management
WG	Working Group

Acknowledgements

Active UK Working Group Nominees and Scientific Representatives (s)

Professor Paul Bardos (s), r^3 environmental technology ltd	WG2 Decision Support
Mr Paul Beck, CLAIRE	WG7 Technologies
Dr Naomi Earl, WS Atkins (was Land Quality Management at the University of Nottingham)	WG6 Human Health Aspects
Mr David Edwards, exSite Research Ltd	WG7 Technologies
Mr Bob Harris (s), Environment Agency	WG3 Protection of Water Resources
Mrs Judith Lowe	WG1 Brownfields Redevelopment, and CLARINET Overview Report Editor
Dr Dan Osborne CEH- NERC	WG4 R&D Programmes and Collaboration
Dr Simon Pollard, Cranfield University (was Environment Agency)	WG6 Human Health Aspects
Dr Ben Sykes, BBSRC	WG4 R&D Programmes and Collaboration
Ms Clare Scanlon, SEPA	WG5 Ecological Requirements for Land Reuse
Mr Steve Smith, WDA	WG1 Brownfields Redevelopment
Dr Jason Weeks, WRc - NSF	WG5 Ecological Requirements for Land Reuse
Professor Geoff Williams, BGS	WG3 Protection of Water Resources

Other UK Contributors

Mr Malcolm Barton	Contributor to CLARINET Final Conference
Professor Bob Kalin, Queens University	Meeting participant
Mr Malcolm Lowe DTLR (was DETR)	Country Representative and CLARINET Steering Committee Member
Mr Steve Milsom EPSRC	WG4 contributor
Dr Paul Nathanail	Meeting Participant and WG7 contributor

In memoriam. The late Professor Colin Ferguson was originally one of the UK scientific representatives and nominee for Working Group 6. Following his untimely

death, his role in Working Group 6 was been taken over by his colleague from Nottingham University, Dr Naomi Earl. Mr Bob Harris of the Environment Agency took over as a scientific representative. Professor Ferguson's CLARINET colleagues gratefully acknowledge the substantial contribution he made to the work of this network.

1 Introduction

CLARINET, the Contaminated Land Rehabilitation Network For Environmental Technologies in Europe was a Concerted Action of the European Commission's Environment and Climate Research and Development Programme. The project ran from 1998 to 2002. It's primary objectives were to develop technical recommendations for sound decision making on the rehabilitation of contaminated sites in Europe and to identify research and development needs, in particular in relation to the recent EC Fifth Framework Programme (FW5). The Austrian Federal Environment Agency has published a series of CLARINET reports as hard copy, on CD ROM and on *www.clarinet.at*. This report series includes an Overview Report, and more detailed reports from a number of its Working Groups.

CLARINET's findings represent a consensus between experts from 16 European countries[1] and address both a philosophical framework for contaminated land management now, and in the future, *Risk Based Land Management*, and a series of findings related to the specific interests of its seven Working Groups. These Working Groups were:

Working Group (WG) 1 "Brownfields and Redevelopment of Urban Areas"

WG 2 "Decision Support"

WG 3 "Groundwater and Surface Water Protection"

WG 4 "Research Programmes and Collaboration in Europe"

WG 5 "Ecological Requirements for Land Reuse".

WG 6 "Human Health Effects"

WG 7 "Remediation Technologies"

* Report available for download from www.clarinet.at

Each Working Group followed a programme agreed by its members, which differed in approach from group to group. These findings were integrated in the overall findings of CLARINET about *Risk Based Land Management (RBLM)*.

This report sets out the nature of the UK participation in CLARINET. It describes the outputs and activities of CLARINET, and then briefly reviews other international networking initiatives. Finally it evaluates the benefits of the UK participation in CLARINET.

[1] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom

2 UK Participation in CLARINET

The United Kingdom vision for land quality is to see more contaminated land made safe and brought back into beneficial use via an integrated approach which also includes preventing and controlling new land contamination. One of the principal aims is to secure the remediation of contaminated land. To support this, the UK contributes to key national and international developments in the area, and this included CLARINET. In particular the UK participated in CLARINET through:

- a national ("country") representative;
- two scientific representatives;
- support for UK experts to take part in CLARINET working groups; and
- providing access to CLARINET for other interested parties throughout the UK.

UK involvement in CLARINET was supported and co-ordinated by the Department for Environment, Food and Rural Affairs (DEFRA), with the assistance of a contractor, r^3 Environmental Technology Limited.

DEFRA also asked a number of individuals and organisations to take a voluntary role in CLARINET's seven Working Groups, (see the Acknowledgements section), the Working Group "nominees". Nominees from different countries were approached by most CLARINET member countries. Their role was to ensure that as wide a contribution as possible is made from each country and to augment the work of the formal UK participants. They were to act as focal points for researchers and practitioners interested in the activities of particular Working Groups to help ensure both dissemination of information to and from CLARINET.

DEFRA also provided additional inputs to CLARINET including:

- support for editing the final CLARINET Overview Report
- support for a workshop during 2002 in the UK to evaluate prospects for an EC network of contaminated land demonstration sites
- support for a workshop to disseminate CLARINET findings in the UK held in Nottingham in March 2002
- support for the preparation of the WG2 Final report and a WG2 "Special Session" of the 7th International FZK/TNO Conference on Contaminated Soil, 18-22 September 2000, Leipzig, Germany and its open access catalogue of decision support tools.

Deliverables from the DEFRA project contract are listed in Annex 1.

The Environment Agency supported the participation of a number of its own experts and a work shop on the role of epidemiology in human health risk assessment for contaminated land with WG6. The Environment Agency also supported the co-ordination of European collaborators input into a NATO/CCMS Pilot Study Session on Decision Support for Contaminated Land Management, which provided a strong input to WG2's efforts.

Finally a number of individual contributions were made to CLARINET, as listed in the acknowledgements section.

3 CLARINET's Outputs

The principal CLARINET output was the Report "Sustainable Management of, Contaminated Land: an Overview". This report presents an overview of the work of the CLARINET project. It describes the background to the CLARINET work and presents the concept of "risk based land management" or "RBLM". This concept was developed during the course of the CLARINET work to provide a framework for development of policy, research and practice in sustainable management of contaminated land. The report also discusses some of the key topics addressed by CLARINET Working Groups in the context of RBLM. The report is based on information exchanges and joint activities between Member States of the European Union, but addresses topics that are also of relevance to other countries, in particular those in Central and Eastern Europe. Its intended audience is a wide range of people with an interest in land contamination issues, including policy makers and research managers, as well as scientists, practitioners and other stakeholders.

In addition CLARINET held a Final Conference in June 2001, whose proceedings have also been published.

Many of the Working Groups also published detailed final reports on their specific topics:

- Brownfields and Redevelopment of Urban Areas (WG1)
- Review of Decision Support Tools for Contaminated Land Management and their use in Europe (WG2)
- Contaminated Land and its Impact on Water Resources (WG3)
- An Analysis of National and EU RTD Programmes related to sustainable Land and Groundwater Management (WG4)
- Remediation of Contaminated Land. Technology Implementation in Europe -
- State-of-the-Art (WG7)

All of these publications are freely downloadable from www.clarinet.at which will be kept open for the foreseeable future.

In addition, CLARINET stimulated a number of "Satellite" Publications:

- Proceedings of the CLARINET Workshop on Ecological Risk Assessment, April 17-19, 2001 Nunspeet, The Netherlands. S-TEC 2001
- Environment Agency for England and Wales, June 2001: Epidemiology Workshop on Human Health Tools and Techniques - Report; Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4DU
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- Frank Swartjes, 2002: Variation in calculated human exposure: Comparison of
- calculations with seven European human exposure models (in press) - RIVM
- report 711701030; Amsterdam 2002.

These reports are also downloadable directly (or via hyperlinks) from www.clarinet.at

4 Risk Based Land Management – A Summary

Risk Based Land Management[2] is primarily a framework for the integration of two key decisions for remediation of contaminated land:

- **The time frame**: this requires an assessment of risks and priorities, but also the consideration of the longer term effects of particular choices
- **The choice of solution**: this requires an assessment of overall benefits, costs and environmental side effects, value and circumstances of the land, community views and other issues.

These two decisions have to take place at both an individual site level and at a strategic level, especially as the impact of contaminated land on the environment can have not only a large scale regional dimension but also potentially wide ranging long term impacts. The decision making process needs to consider three main components which form the core of the RBLM concept:

- fitness for use
- protection of the environment, and
- long-term care.

The first two describe the goals in relation to a safe use of the land, including prevention of harm and resource protection. The third allows for a more rigorous assessment of the way to achieve these goals in a sustainable way. The three components need to be in balance with each other to achieve an appropriate solution (see Figure 1).

4.1 The Aim of RBLM

The aim of the RBLM concept is to achieve the integration of approaches originating from different perspectives (for example spatial planning, environmental protection and engineering), based on the identification of common goals:

- Comparable levels of protection of health and the environment, taking into account local characteristics;
- Optimised use and development of technical and administrative solutions; and
- Sustainability - evaluating and optimising environmental, economic and social factors

The concept applies at different scales – site, regional, national – and covers the whole cycle of risk assessment and risk management of contaminated land. It is driven by current and emerging scientific knowledge. It links to wider themes, in particular to soil protection, spatial planning, and water catchment management.

[2] This section of the report is an extract from Vegter, Lowe and Kasamas "Risk-Based Land Management – A Concept for the Sustainable Management of Contaminated Land, to be published in *Land Contamination and Reclamation in 2003*

The concept also applies at a strategic level. However, it has practical application at a site specific level: the operational details of treatment, monitoring, aftercare and other risk management techniques (containment techniques for instance) can be assessed using the RBLM concept on a site-specific basis.

Figure 1: The architecture of RBLM

4.2 THE COMPONENTS OF RBLM

Fitness for use

Fitness for use depends on reducing risks to human health and the environment as necessary to ensure the safe use or reuse of the land. It focuses on quality requirements of the land for uses and functions, and takes into account the timeframe of the particular use of the land – for example the assessment considers how long a receptor might be exposed to contamination.

Risks related to the use of the land should be “acceptable” for the people concerned. This acceptance might be obtained if the quality of the land meets certain minimum quality requirements. In some cases, obtaining acceptance might require additional quality requirements to create confidence and security. It is essential in determining the “total quality requirements" to know all the aspects of the site use. This will ensure that the requirements are appropriate. It is also necessary to consider the future activities and controls on the site to ensure that long term risks are also managed, and that the land will continue to be "fit for use" in the future.

Making certain choices about the management of the land can not only achieve the necessary quality requirements in relation to immediate fitness for use but also improve the quality of the land over time. For example, introducing additional gradual

treatment would open up opportunities for land use changes, more biodiversity and less long-term care.

Protection of the environment

Protection of the environment is related to the wider effects, in contrast to those only related to the use of the site[3]. It has two objectives:

- To prevent or reduce negative impact on the natural surroundings, including ecosystem health and biodiversity;
- To conserve and, if possible, enhance the quality and quantity of resources (for example land, soil, water, or cultural heritage)

Accepted principles like the *precautionary principle*[4] and the *preventive principle*[5] apply to both these objectives.
Preventing or controlling the dispersion of contamination from a site to the surroundings may often achieve both objectives. For example, preventing further spreading of pollution by surface water and groundwater can be a component of overall risk reduction for contaminated land. Being able to achieve both objectives depends on the uses, functions and characteristics of both the land and the surrounding environment.

The requirement to achieve both fitness for use and protection of the environment means that solutions have to be chosen carefully. A solution that meets only the fitness for use requirements is probably not the best solution if it creates potential problems in surrounding areas. A solution that manages the dispersion risk may be different from the solution that manages risks to achieve "fitness for use".

Solutions may in turn lead to the exploitation of other resources, such as energy reserves, or land capacity for disposal. Other environmental and spatial planning policies will aim to protect these resources and a balanced decision - or new solutions - will be needed where there is conflict between the objectives of risk reduction and conservation of resources.

The decision to conserve land or soil as a resource may lead to policies favouring redevelopment of brownfields – land previously used, for example by industry, which may be affected by contamination - over greenfields. This in turn may lead to increased pressure to develop new solutions to deal with the risks to health and the environment. It also shows the need for strategies to prevent sites from becoming brownfields.

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[3] In the UK the term **suitable for use** combines the two concepts of fitness for use and protection of the environment (DETR Circular 2/2000; DoE news release 654/1994)

[4] **Precautionary principle:** Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Rio Declaration, 1992)

[5] **Preventive principle** The state of the environment should not get worse as a result of pollution that can be avoided. Further pollution of already polluted areas should be avoided. The principle also implies that accumulation of persistent substances in the environment should be stopped (UN-DPCSD, 1995)

Long-term care

If a solution leaves contamination in the soil, there is a need for long-term care. Monitoring and control may be necessary to ensure that the solution remains appropriate, that it continues to work and that any restrictions on future choices regarding the land use are enforced.
Solutions that are based on the current use only, or rely on specific restrictions on land use need additional documentary records. Taking into account the social and economic burden of long-term care and the risk of failure is essential in identifying sustainable solutions.

4.3 How RBLM Can Work in Practice

The way in which the balance between the three components of RBLM is achieved will be different for different treatment approaches. Over the past fifteen years, developments in contaminated land policies and the emergence of a wide range of treatment approaches have broadened the repertoire of potential solutions for contaminated land problems. There can be other options rather than only 'dig and dump' or containment.

However, it is clear that there is no universally practical solution. Each solution has its advantages and disadvantages, which depend on a wide range of factors and requirements, such as:

- nature of the contamination
- physical characteristics of the land
- use of the land, either current or planned
- the environmental setting, in particular ecosystems and buildings
- the hydrogeological characteristics and impact on water resources,
- nature of impact on community
- local and regional practicalities.

These factors and requirements vary from one situation to another, and as a result the practical availability and appropriateness of solutions needs to be determined on a site-specific basis. The overall balance of disadvantages and benefits can then be determined for those options which are technically possible. RBLM provides a framework for determining this balance in practice.
The choice of any specific practical option, either at a strategic policy level or for a particular site, needs to take into account the extent to which the land meets any fitness for use criteria, achieves adequate protection of the environment or needs longer term care. This assessment is complex, and has already generated a demand for decision support tools, which may vary from straightforward information about the broad advantages and disadvantages of various options to formalised weighting systems.

The RBLM process (set out in Figure 2) addresses the issues that the risk based land manager has to address in order to ensure a sustainable solution include:

- Risk reduction
- Land use related requirements

- Using natural capacities in the soil and water environment
- Costs
- Involving stakeholders
- Managing uncertainties
- Other management constraints and influences

To assist in making the decisions these issues are discussed based on the underlying three components of risk based land management: *fitness for use, protection of the environment and long term care*.

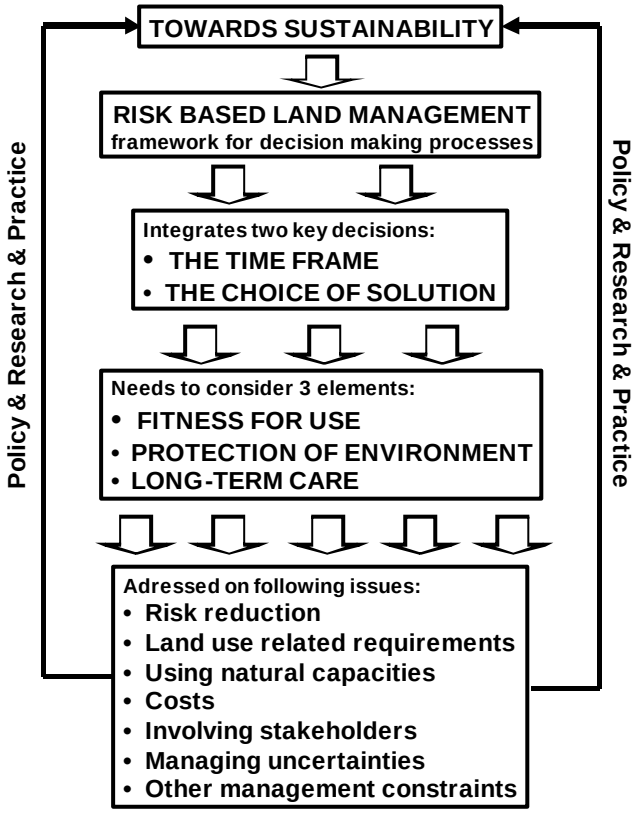


Figure 2: The RBLM process

5 Working Group Findings

WG 1 "Brownfields and Redevelopment of Urban Areas"

At present in Europe the term brownfield is used in different contexts and means slightly different things. In some countries, the complexity and context of this term is not recognised. However, all countries in Europe face a significant problem from land used in the past in a way which has left the land not fully suitable for new uses. CLARINET therefore established a working definition of the term brownfield to assist in identifying and comparing issues in different countries Brownfield sites:

- have been affected by the former uses of the site and surrounding land
- are derelict or underused
- have real or perceived contamination problems
- are mainly in developed urban areas
- require intervention to bring them back to beneficial use

WG1 carried out a review of national approaches fir the redevelopment of brownfields across CLARINET countries, considering:

- future use;
- site preparation;
- economic viability;
- legal framework.

The review found that:

- Contamination is a technical barrier in site preparation;
- The real and perceived future risks from contamination inhibit reuse of the land;
- Developers face complex legal requirements in dealing with contamination;
- The cost of dealing with contamination can inhibit redevelopment.

Whilst the presence of contamination can be a serious obstacle in the complex process of redevelopment, brownfield sites also have other, wider problems, many of which are related to the factors that caused the land to become unused, underused or only partially used. These include: the economic factors that caused the decline or cessation of the former use of the land, social problems which have resulted from this economic decline and the environmental impacts of underused (and possibly contaminated) land.

These problems are not entirely new. Many countries have already introduced policies and programmes aimed at regenerating areas of industrial decline and reusing brownfields. The benefits of reusing brownfields are increasingly recognised for providing urban, economic and social revitalisation, restoring the environment and contributing to the reduction of the consumption of “greenfield” land.

The lack of a common definition underlying the data obtained from different countries makes it difficult to quantify the scale of the brownfield problem over Europe. However, there are some general indications of the nature and extent of the problem. Three main categories of brownfield can be identified:

- Brownfields in traditional industrial areas which have declined (especially in the coal, steel and textile areas, but nowadays also in the chemicals and power sector);
- Brownfields in metropolitan areas (which include infrastructure such as railways and docks and some of the 19th century smaller industrial uses);
- Brownfields in rural areas (mainly associated with agriculture, forestry, mining or military activities).

In almost all countries there are large-scale regional problems, such as those in the Ruhr area, in Catalonia and in South Wales, as well as urban problems, in particular

in cities of rapid growth such as Helsinki and Dublin, and rural problems, such as those in Lavrion/Attika. The candidate countries for the European Union are affected in some cases at a greater scale.

The creation of brownfields continues through the closure of industrial facilities not regulated under current legislation nor with any restoration obligations. Furthermore, some newer industries or uses of land (created on former brownfields) have not been successful, leading to a return of the land to a derelict or underused state. [NB These do not necessarily result in a return to the levels of contamination or dereliction existing before development as some reclamation/remediation would have taken place.]

Another dimension of the problem relates to the value of the land. Where brownfield land has a high potential value for reuse minimum treatment for the uintended re-use might have taken place – for example to keep project timescales short. This not all contamination issues for other types of use might have been addressed. Where the land does not has very limited economic value, the land may be abandoned forever as there is no incentive for remediation. These scenarios are common across Europe.

A variety of environmental and land use related legislation may be used to control brownfield redevelopment. Typically this can include:

ENVIRONMENTAL CONTROL	*DEVELOPMENT CONTROL*
Soil quality requirements Contaminated site controls Water legislation Waste legislation Emissions (or pollution) control	Spatial planning policies Urban design requirements Building codes Mining codes

At present, there are differences in the policies published for brownfield reuse in different countries. This reflects partly the differences in extent (or perception) of the problem and also the different legal and administrative structures for action. It also reflects a real difference in the drivers for brownfield reuse. In cases where the real need is to stimulate economic growth in disadvantaged areas, or to find land for housing or other uses, the reuse of brownfield is encouraged. Where land is cheap, and the cost of treating brownfields is high, the economy cannot always afford reuse. Whether or not there are different policy approaches, there is a common problem in the integration of spatial planning and environmental considerations within the economic framework of each country. Spatial planners must concentrate on balancing a wide range of factors in relation to land use. If contamination is one of the factors, but is very complex, it is difficult for spatial planners to identify all the possible impacts of the contamination and to decide how best to deal with the issue.

To the investor in reuse of brownfield sites the problem is simple and common to all countries – what are the incentives and what are the obstacles to economically viable development?

Working Group 2 "Decision Support"

Decision support exists to help those who have to take decisions deal with the complex and wide-ranging information involved in contaminated land management. *Decision suppor*t can be defined as 'the assistance for, and substantiation and corroboration of, an act or result of deciding'. Typically the decision required will be the determination of a best approach for particular action to take place in a particular set of circumstances. WG2 surveyed decision support issues across the 16 CLARINET countries.

Decision support can be provided as written guidance (flow sheets, model procedures) and/or software. It aims not only to facilitate decision making but to help ensure that the process is transparent, documented, reproducible and hopefully robust, providing a coherent framework to explore the options available. The need for decision support is widely recognised and in recent years a large number of decision support tools (DSTs) have been developed, with varying degrees of success in practical use. These are used to identify the range of options for solutions that best fit the constraints of the problem they are addressing.

WG2 Outputs

WG2 Report. The report reviews the Working Group's view of the principal decision making criteria for contaminated land management and remediation: driving forces for the remediation project, risk management, sustainable development, stakeholder satisfaction, cost effectiveness and technical feasibility. Chapter 3 reviews the practice of decision support, and techniques commonly used to provide analyses for decision making: environmental risk assessment, multi-criteria analysis, multi-attribute techniques, cost-benefit analysis, cost effectiveness analysis, life cycle assessment, financial risk management; and their acceptability in the decision making process. Chapter 4 (and Annex A) report on a survey of decision support issues carried out over 16 European countries by WG2, and introduces an on line catalogue of decision support tools. Chapter 6 discusses decision support in the context of the Risk Based Land Management concept developed by CLARINET. The final chapters contain the reports conclusions and recommendations.

On-line Catalogue WG2 established an open access catalogue of decision support tools, on which information about commercial decision support tools, or tools under development can be posted or viewed by anyone. The catalogue can be accessed via www.clarinet.at.

Finding sustainable technical solutions for contaminated problems is dependent on a range of parallel considerations. Key factors in decision making are the reasons for

the remediation work and any constraints on it, risk management effectiveness, technical suitability and feasibility, stakeholders' views, cost/benefit ratio and wider environmental, social and economic impacts (i.e. sustainable development), which need to be considered in an integrated and holistic way (Figure 3). A case study is provided in a paper in *Land Contamination and Reclamation*[6]

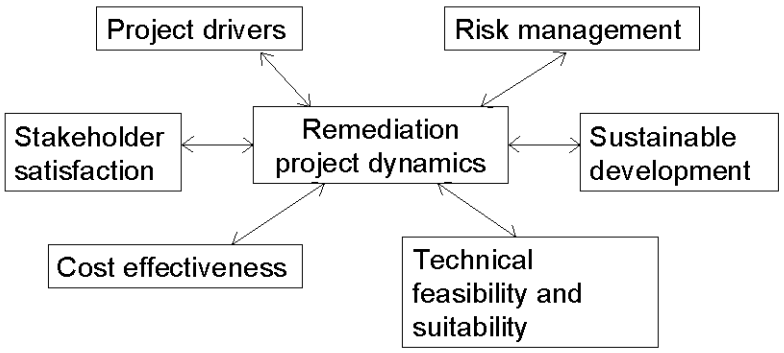


Figure 3 General Principles for Remedy Selection

Decision support codifies specialist expertise in a way that allows its reproducible use by many. It integrates specific information about a site and general information such as legislation, guidelines and know-how, to produce decision-making knowledge in a way that is transparent, consistent and reproducible. Decision support tools (DSTs) can be distinguished by their:

1. *Functional application* The functional application to contaminated land management describes whether the decision support is for risk management, remediation, monitoring and aftercare, sustainable development etc. This deals with the issues that must be addressed to support the overarching decision. In practice, a number of DSTs address multiple decision criteria.

2. *Analyses used* Several different techniques can be employed to assist environmental decision-making. In practice, many decision support tools use several of these techniques, or mixtures of different parts of them. For example, software tools might combine risk assessment and cost-benefit analysis techniques to generate risk maps, cost comparisons between remedial options and other decision information, such as optimal risk solutions.

3. *Decision making role* The decision making role describes the type of decision making being supported, e.g. for managing a single site, or for prioritising a number of sites. This deals with the overarching decision being made at the site.

[6] Bardos, R.P., Nathanail, J. and Pope, B. (2002) General Principles for Remedial Approach Selection. Land Contamination and Reclamation 10 (3) 137-160

4. *Nature of the product* whether the tool is written guidance; a "map" of some sort, a series of procedures or a software based system.

The analytical tools used in DSTs like multicriteria analysis (MCA) are reviewed in greater detail in the WG2 Final Report, and a number of DST case studies are presented. These include:

- Examples of DSTs using risk assessment (Spatial Analysis and Decision Assistance, USA)

- Examples of DSTs using MCA (Conceptual Framework for Wider Environmental Value, UK; Decision Aid for Remediation Technology Selection, Italy/UN)

- Examples of DSTs using cost-benefit or cost-effectiveness analyses (The WILMA System for Cost benefit analysis / multi -criteria analyses for a remediation project, Germany; Land Value Balance, Germany; Methodology for Assessing the Full Costs and Benefits of Groundwater Remediation, UK; Cost Benefit Analysis for Remediation of Land Contamination, UK; Environmental Visualization System Pro, USA)

- Examples of DSTs using life cycle assessment (Environmental and Economical Evaluation and the Optimising of Contaminated Sites Remediation, Denmark/Norway; REC System, The Netherlands; Environmental Balancing of Soil Remediation Measures, Germany)

- Other Examples (The “Model Procedures”, UK; SiteProTM, USA; ArcView® GIS, USA; SamplingFX, USA; GroundwaterFX, USA; RBCA, USA)

A variety of techniques have been applied in commercial DST products, and yet others are under development. DSTs are now widely used in contaminated land management for a number of decision making applications. The most successful software based tools tend to be fairly specific, focusing on providing specialist support for niche decision making, for example determining sampling strategy. Applications of techniques using MCA, cost benefit analysis (CBA) are widespread as written guidance, but have not found wide acceptance in software applications.

More general tools, for example for remedy selection, are less well developed and accepted, either in software or written guidance, although, again, written guidance tends to have a wider acceptance than software systems.

There is something of a lack of trust in many decision support tools, particularly if they are software based. This is often related to their lack of transparency, in particular the methods and assumptions involved. There have also been relatively few studies carried out bench marking different techniques against each other, or testing their ability to support effective and reproducible decision making in practical land management circumstances.

Furthermore, while a risk management approach is broadly accepted by technical specialists and contaminated land professionals as the most appropriate decision making basis for contaminated land management, this acceptance is not universal for all stakeholders, particularly "lay" consultees

Two major, and as yet unachieved goals, for decision support are to be able to:

- Consider sustainable development and risk management in a mutual and holistic way, and

- Support stakeholder engagement in a way that is robust and transparent, even to lay audiences

These goals create a tough challenge because any decision support must not hamper efficient and cost effective decision making or cause excessive delay. A major concern of site owners is that, by widening their considerations and their consultees, they run the risk of stalling the decision making process; or making it so difficult that, for instance, brownfield remediation becomes less attractive.

WG 3 "Groundwater & Surface Water Protection"

Groundwater and surface waters are vital, natural resources for our daily life. However, all countries are facing significant contamination of these resources caused by contaminated land which originates from former industrial activities and improper waste disposal. Groundwater is particularly vulnerable. As well as being the main source of drinking water in most European countries, groundwater is also a vital component of surface waters and many rivers and other aquatic ecosystems are heavily reliant on groundwater baseflow.

When large bodies of groundwater become polluted, the quality of surface water systems will be seriously affected. Surface waters and groundwater are in principle renewable through natural processes, but the formation and the renewal of groundwater can in particular show very long time lags.

The European Groundwater Directive sets a need to protect all groundwater, even if they are not considered for current and future uses. Groundwater is also addressed by the European Water Framework Directive[28], which has been issued to prevent further deterioration, and to protect and enhance, the quantity and quality of aquatic ecosystems. As a key element of this Directive, improvements in *ecological* quality of surface waters are to be achieved through a staged and iterative process of River Basin Management Planning, encompassing:

- characterisation of River Basins;
- analysis of pressures;
- environmental monitoring;
- drawing up River Basin Management Plans, which are statutory and require public participation;
- implementation of a programme of measures.

This Directive may provide an additional legislative driver for the remediation of contaminated land. The achievement of good status of all waters within 15 years, in particular the good ecological status of rivers will also encourage the management of point source and diffuse contamination and other environmental sources of pollution, such as contaminated sediments.

Contaminated land has been usually considered in two separate contexts: human and/or ecosystem health and water pollution. The former has often been seen as the most important political driver for clean-up on a local scale, but the Water Framework Directive will be an important legislative driver common to all European countries in the future.

WG3 carried out a survey of all CLARINET participants, representing most of the European Union Member States, to establish a common understanding of different countries approaches and underlying differences in relation to water resources management, groundwater protection and remediation, and to identify important issues at a European level. Its main findings are as follows.

The principles that underlie the risk assessment approach to water resources in Europe are:

- definition of the sustainability of the resources;
- prevention of new pollution;
- understanding of primary role of groundwater (drinking water resource and/or providing baseflow to rivers or wetlands, but also as specific ecosystem to be protected for its own sake);
- remediation of past pollution where this is necessary to protect the aquatic environment, terrestrial ecosystems and water users.

There are differing perspectives across Europe about the importance of groundwater as a source of drinking water. This is because the reliance on groundwater for drinking supply is highly variable on a regional scale both within Europe and within individual countries and is clearly related to the geographical distribution of aquifers. Also there are cultural differences. Some countries will accept remediation by treating groundwater before supply whilst others will not.

The points of compliance used in regulations for both protection ("new" pollution) and remediation ("old" pollution) of water resources are differently defined in the European countries due to differences in national regulations or differences in the interpretation of EU regulations, as illustrated in Figure 4.

The Groundwater Directive and the Water Framework Directive are highly precautionary in its approach in preventing new pollution. The point of compliance for List I substances is therefore the top of the water table. This applies to **all** groundwater regardless of use. However, for historical pollution a more risk-based approach may be taken which may account of the use of the groundwater, the feasibility of cleaning it and the pathway influences (e.g. natural attenuation).

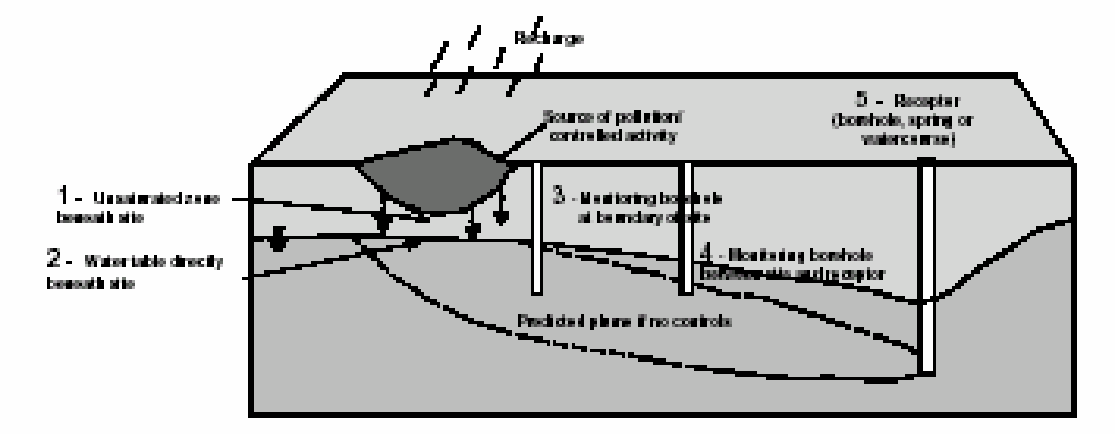


Figure 4 Points of Compliance

In many cases, it will not be possible to deal immediately with all groundwater pollution from contaminated land, and long-term care is likely to be a key feature of the interface between contaminated land and groundwater. This may require long term control over a considerable land area. Hence land use planning controls will have an important part to play in applying this approach.

Important issues for further investigation included the following:

- Fundamental science to develop better solutions – in particular knowledge about natural processes, interactions between contamination and the effect of hydrogeological and biogeochemical factors.

- Acceptable levels need to be set for water quality for residual pollution for environmental protection.

- To consider Monitored Natural Attenuation (MNA) as an acceptable option in the 'appropriate' circumstances, the time scale could be an important limit (30 or 50 years may be necessary to achieve the remediation goal). Questions about liabilities in the long term, particularly if the approach fails, needs to be addressed.

- Dealing on a wider scale with cumulative risks - such as those which occur in urban areas – or with integrated implementation of solutions should be considered.

WG 4 "Research Programmes and Collaboration in Europe"

WG4 included national research programme managers from 11 European countries and EC DG Research from the EU. It carried out a survey of national and EU research programmes related to sustainable land and groundwater management issues. Key findings of this survey are as follows.

- Budgets of national RTD programmes in Europe add up to a total of about € 20 million /year and about € 10 million from the EU budget (as of 2001). Altogether, there are about € 30 million/year available for contaminated land and groundwater research across Europe. The annual investment in RTD for sustainable land management is only about 0.03 % of the total cost of the problem. The research programmes identified are listed in Annex 2.
- Before WG4, there was no co-ordination whatsoever between national research, technology and development (RTD) programmes in Europe for this sector. The consequence is that all countries go through similar learning curves, resulting in a considerable overlap of research projects and targets.
- Eligibility for national RTD programmes is usually restricted to countries' own national research community. This means that cross-fertilisation and knowledge exchange among countries using focused partnership projects has not been possible.
- Dissemination of project findings through national RTD programmes was felt to be rather modest. Opportunities provided by the Internet are not well used.
- There is no co-ordinated approach in focusing the various RTD programmes in Europe towards the major gaps in scientific knowledge.

WG4's overall conclusion was that enhanced co-ordination between countries' national research approaches would considerably increase the effects and yields of the resources invested in RTD, and facilitate the development of a *European Research Area* for this sector. WG 4 recommended taking steps towards establishing a co-ordinated European research policy for contaminated land and water management:

- Providing a platform for research programme managers to exchange information on national research priorities, funding mechanisms and knowledge dissemination;

- Striving for a more coherent integration of national and European research activities. (This could be achieved through a closer collaboration between various scientific and technological research organisations in Europe);

- Taking a joint approach to the needs and means of financing large research projects in Europe. (For example, European researchers and technology developers could test and compare their products at specific demonstration sites in Europe);

- Networking of existing centres of excellence and competence in Europe and the creation of virtual centres through the use of new interactive communication tools;

- Co-ordination of an agenda of joint research priorities and stimulation of trans-national RTD projects and European peer review of programmes;

- Stimulation of trans-disciplinary research involving more stakeholders in the projects (a goal of the many networks summarised in Section 7).

WG 5 "Ecological Requirements for Land Reuse".

WG5 held workshop on Ecological Risk Assessment (ERA) in the Netherlands in 2001 to:

- discuss the scientific development and policy needs for site-specific ecological risk assessment,
- identify available tools
- identify the gaps and needs for future development in this area
- explore possibilities for a European framework for site-specific risk assessment.

The main findings of this workshop are available on *www.clarinet.at*.

WG5 also surveyed the use of ecological risk assessment and the perceived needs for and of this technique among CLARINET countries. Most countries use or intend to use some kind of ecological reasoning in generic guidelines and/or site-specific assessments, typically based on information on plants, soil fauna, micro-organisms and processes. There are important uncertainties in ERA:

- The reliability of extrapolations of "lab" findings to the field,
- Dealing with heterogeneity in test methods,
- Reliability of models,
- Varying expert opinions
- A lack of basic knowledge on soil biota.

A staged approach to ERA is suggested, with increasing levels of sophistication and effort being applied only when the circumstances demand it, illustrated in Figure 5.

The initial tier of assessment should be a practical, easy to implement step that is relatively inexpensive. Tier 1 should include site history (potential contamination), chemistry (analyses and comparison with soil screening levels), and biology (bioassays optional at tier 1). An expert view of the site may provide additional information. If potential risks are identified then assessment proceeds to Tier 2.

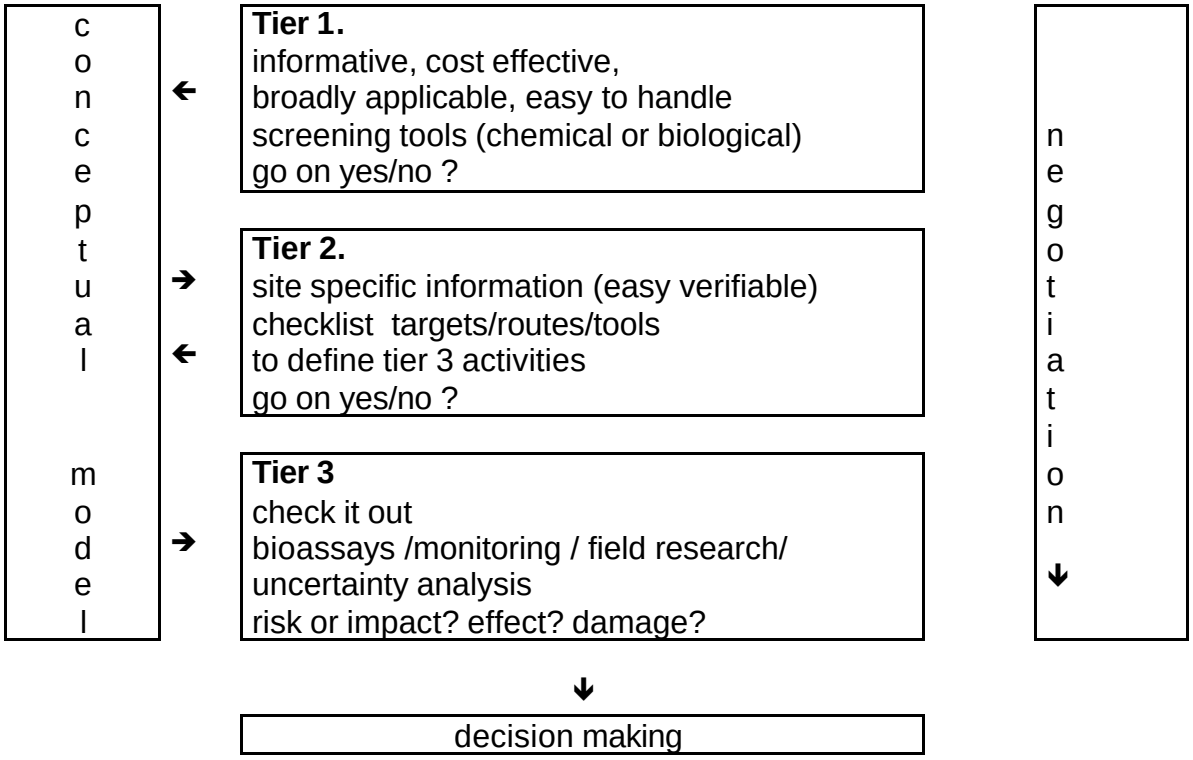
Tier 2 involves more detailed characterisation of physical/ chemical characteristics, ecology and biomonitoring (considering land use and pollutant types). Predictive models may be used. Its aim is to develop site specific acceptance criteria for use in decision making and discussions with stakeholders. If there is insufficient information available to make a decision then the ERA proceeds to Tier 3.

Tier 3 aims to collect further information to reduce uncertainty, for example using mesocosm studies, detailed field studies, advanced modelling and field validation of laboratory measurements and models.

The information collected through the ERA should be incorporated into a site conceptual model[7].

[7] The site conceptual model (SCM), is a vital component in risk management decision making, as it sets out the critical pollutant linkages of concern for a particular land contamination problem [Nathanail, C.P., Nathanail, J., McCaffrey, C. 2002. SCOTTISH EXECUTIVE TECHNICAL GUIDE TO PART IIA IMPLEMENTATION: Assessment of Potentially Contaminated Land. Scottish Executive, Edinburgh (in press)].

Figure 5: Suggested Staged Approach to Ecological Risk Assessment



While the development of a common European framework for ERA is seen as a useful step by WG5, it is important that any such framework is flexible, so that country specific details can be built in. The approach should be tiered, decision oriented and simple. The development of bioassays and interpretation of its results can also be taken up by consisting networks/organisations like for instance ISO,

WG 6 "Human Health Effects"

WG6 produced three main outputs:

1. an international comparison of human exposure model variability[8]
2. a workshop (2001) exploring the potential contribution of environmental epidemiology to contaminated land risk assessment[9]
3. BioAvailability Research Group Europe (BARGE)

[8] Swartjes, F.A. (IN PRESS): Variation in calculated human exposure: Comparison of calculations with seven European human exposure models. RIVM report 711701030. RIVM, Bilthoven, The Netherlands

[9] Environment Agency and CLARINET (2001) Epidemiology Workshop on Human Health Tools and Techniques. Report of a joint workshop, Coventry 14-15th March, 2001, ISBN 1-85-705592-6, Ref. HO 06/01-300-A, Environment Agency, Bristol, 33pp.

International comparison of human exposure model variability

The calculation of human exposure to contaminants can lead to a wide range of results, depending upon the model, parameters selected and model user. The consequences can be far-reaching. Model calculations using different models from seven different European countries were compared (model given between brackets):

- ANPA, Italy *(ROME);*
- DHI Water and Environment, Denmark *(CETOX-human);*
- INERIS, France *(no name);*
- Kemakta Konsult AB, Sweden *(no name);*
- LQM/ University of Nottingham, UK *(CLEA);*
- RIVM, the Netherlands *(CSOIL);*
- VITO, Flanders, Belgium *(VlierHumaan).*

Comparisons were based on the same scenarios, with differences in soil use, soil type and contaminant used in the comparisons. Twenty hypothetical scenarios were used. These scenarios differed the following ways: two land uses (residential and industrial), two soil types (sandy soil and clay soil), and five different contaminants. The contaminants (benzo(a)pyrene, cadmium, atrazine, benzene, and trichloroethene) are of different types and are considered to be common throughout Europe, and have different exposure characteristics.

Results of these comparisons indicate that calculated exposures can vary substantially[10]. This variation in larger for more volatile contaminants, and to a lesser extent, for contaminants that are more mobile, or available for plant uptake. This is partly the result of the use of different exposure factors but more significantly due to the different mathematical formulae used to compute the distribution over the different soil phases and the transfer of contaminants along different pathways. The study found that there is no clear influence from using standardised or "own" input parameters on the variation in exposure. There is also no clear difference between the variation in calculated exposures for residential versus industrial sites, neither for sandy soil versus clay soil.. The impact of choice of model and type of contaminant on variation in calculated exposure is much more evident. Possibly differences in model performance can be attributed to "misunderstandings", i.e. differences in interpretation in definitions of outputs and scenarios.

Environmental epidemiology workshop

A workshop was held in Coventry on the 14th and 15th of March 2001. With the combined objectives of the Environment Agency, CLARINET and its Working Group 6 in mind, the workshop was designed as an awareness-raising event for practitioners. It included technical overviews from expert practitioners in environmental epidemiology and case study material from Environment Agency experience and areas of interest to CLARINET. The principal conclusions of the workshop were as follows.

10 The report can be downloaded from http://www.rivm.nl/bibliotheek/rapporten/711701030.pdf

Epidemiology is a specialist tool. Prior to embarking on an extensive epidemiology study, it is essential to collate all information available in the study area and potential exposure pathways should be clearly established. The actual problem must be clearly defined to ensure that there is a common understanding of the issue being investigated.

The first step is to carry out a focused exposure assessment. It is important to determine at an early stage what data sources are readily available. If little or no monitoring has been undertaken, what is the minimum data set required? What data can be modelled? And what are the minimum data requirements for good quality epidemiological studies? The aim is to characterise the site(s) and population(s) of concern, identifying exposure pathways from the site to the population of interest. It should consider environmental monitoring (e.g. concentrations of contaminants, emissions, etc.) and modelling (e.g. air dispersion or groundwater modelling). The exposure assessment should identify the critical risk aspects by establishing a source – pathway – receptor linkage. Only when a complete exposure pathway linkage has been established should an epidemiology study be considered. The identification of the critical risk aspects will allow for the design of a more targeted epidemiology study.

Detection of low risk excesses is highly dependent of good and accurate exposure assessment. Thus, although accurate exposure data are desirable in any epidemiological study, such data are even more important in environmental epidemiology. Therefore close collaboration between environmental epidemiologists and other experts with good knowledge of the exposure data is essential.

However, many epidemiological studies will not have enough resolution to highlight the cause of a statistical significance between the exposed and control populations. Detection and attribution of chronic health effects with exposure is rarely achieved.

BioAvailability Research Group Europe

Ingestion of soil is a dominant exposure route for humans. After soil ingestion, contaminants can be partially or totally released from the soil matrix during digestion. The fraction of the contaminant that is mobilized from soil into the digestive juice (chyme) is defined as the bioaccessible fraction. This fraction is considered to represent the maximum amount of contaminant available for intestinal absorption.

In risk assessments it is currently assumed that the oral bioavailability of contaminants ingested with soil is the same as with food or aqueous solution. However, it is widely believed that this yields an overestimation of the risk. In the absence of more detailed information, the default value used for relative oral bioavailability is commonly 100 %. This default value is used in most guideline values (trigger values, intervention values, soil screening levels, etc.). A more realistic value and approach could have important economic consequences and may lead to more transparent decision making in areas with high natural background levels of potentially harmful substances. Better assessment of oral bioavailability is especially important for contaminants like lead, arsenic and polyaromatic hydrocarbons.

BARGE was set up in December 1999 for co-operation and exchange of data on oral bioavailability for soil contaminants. Participants agreed to compare the five existing *in vitro* digestion models (listed in Table 1) by using three identical soil samples each containing three contaminants (As, Cd and Pb) in a "round-robin" experimental set-up.

Table 1 Different types of *in vitro* digestion models within the BARGE.

Method	Institute	Country	Type of digestion model
SBET	BGS	UK	Static gastric model
DIN	RUB	D	Static gastro-intestinal model
In vitro digestion model	RIVM	NL	Static gastro-intestinal model
SHIME	LabMET/Vito	B	Static gastro-intestinal model
TIM	TNO	NL	Dynamic gastro-intestinal model

A wide range of bioaccessibility values were found for the three soils: for As 6–95%, 1–19%, 10–59%; for Cd 7–92%, 5–92%, 6–99%; and for Pb 4–91%, 1–56%, 3–90%. Bioaccessibility in many cases is less than 50%, indicating that a reduction of bioavailability can have implications for health risk assessment. Although the experimental designs of the different digestion systems are distinct, the main differences in test results of bioaccessibility can be explained on the basis of the applied simulated "gastric" pH. High values are typically observed for a simple gastric method, which measures bioaccessibility in the gastric compartment at low pHs of 1.5. Other methods that also apply a low gastric pH, and include intestinal conditions, produce lower bioaccessibility values. The lowest bioaccessibility values are observed for a gastro-intestinal method which employs a high gastric pH of 4.0. Differences in the applied gastric pH in the various *in vitro* digestion models, also correspond to different physiological conditions, i.e. fed and fasted state.

Further information on BARGE and participation in BARGE is available from: *www.schelwald.nl/pages/barge.*

WG 7 "Remediation Technologies"

Several billion EUROS are spent in the EU each year on the remediation of land affected by contamination. It is an important goal from all perspectives that this money is spent wisely and appropriately. A risk based decision-making process for remediation is now the norm across most EU member states (CLARINET and NICOLE, 1998). In this process, risk assessment and the subsequent step of risk management are intimately related elements that form the basis for a fitness-for-use approach to land affected by contamination[11].

[11] Ferguson, C., Darmendrail, D., Freier, K., Jensen, B.K., Jensen, J., Kasamas, H., Urzelai, A. & Vegter, J. (1998) "Risk Assessment for Contaminated Sites in Europe. Volume 1. Scientific Basis", Report of CARACAS

The WG7 report reviews the use of remediation technologies in different CLARINET countries. The key findings of this study are as follows.

- The future use of land, and the money available for developing this use, are powerful controlling influences on the remediation approaches used. There is a constant pressure for lower remediation costs, both to improve the economics of brownfield re-use for "hard applications" such as housing or commerce; and for "softer" uses such as for “green space”. Cost effectiveness is not just a product of reducing remediation costs, but also of finding remediation approaches that provide an additional enhancement to the value of the land.

- In many countries waste management legislation, taxation and regulation has a controlling influence on the economic viability of different remediation approaches, affecting in particular the viability of treatment based techniques[12].

- The importance attached to the protection of groundwater varies between countries, and this seems to be associated with the degree of utilisation of groundwater. For example, in countries like Norway, where only 15% of the groundwater resource is utilised for water supply, remediation is rarely initiated to protect the groundwater.

- Assuming that a remedial approach can be adequately monitored and controlled, there is an increasing desire to promote *in situ* over *ex situ* solutions and on site solutions over solutions based on removal off site. However, there are often conflicting pressures affecting whether or not an on-site or off-site approach is taken. In some cases stakeholders may express a preference for a solution based on removing materials off site. This may be related to concerns over residual liabilities, which in turn are related to concerns over the duration, feasibility or completeness of on site solutions. Offering previously validated solutions and developing an appropriate verification strategy for the sites in question are key steps in dealing with these concerns. Conversely, removal of materials off site may be problematic because of the transportation and related problems, or because excavation is not considered technically or economically feasible.

- In general, concerns over feasibility tend to be greater for innovative remedial approaches, even if these have long standing track records in other countries.

Project: Concerted Action on Risk Assessment for Contaminated Sites in the European Union. LQM Press, Nottingham, and
Ferguson C. C. and Kasamas, H. (1999) “Risk Assessment for Contaminated Sites in Europe. Volume 2. Policy Frameworks.” Report of CARACAS Project: Concerted Action on Risk Assessment for Contaminated Sites in the European Union. LQM Press, Nottingham. ISBN 0953 309010.

[12] Treatment based approaches destroy, remove, or detoxify the contaminants contained in the polluted material (e.g. soil, ground water etc).

However, it is often these innovative solutions that are seen to offer more in terms of reducing wider environmental impacts and furthering the cause of sustainable development.

WG7 attempted to review remediation costs in the different CLARINET countries, but found difficulties in obtaining comparable cost figures for different technologies. Costings are approached differently in different countries, and are in any case dependent on site specific circumstances. It was noted that generally quoted "unit" prices, e.g. on a per tonne basis, seemed higher than costs bid for large remediation projects. Costs reported for the same technology varied by orders of magnitude. Costs are also related to the availability of the technologies in some countries, and the size of the remediation market, as well as varying views about technology definitions. The tentative cost data collected are as follows:

Predominantly ex situ technologies:

- Bioremediation: 20-40 Euros/tonne, assuming that:
- Low cost figures are referring to composting, and
- High cost figures are referring to bioslurry or reactor treatment system
- Soil washing 20-200 Euros/t
- Stabilisation/solidification 80-150 Euros/t
- Incineration treatment 170-350 Euros/t
- Thermal treatment 30-100 Euros/t
- In situ technologies: 20-60 Euros/t, depending on technology and application site.

Key areas for future remediation R&D identified by WG7 included the following:

- Collating comparable cost data
- Developing quality assurance and control systems
- Providing opportunities for verifiable field scale demonstrations of treatment based remediation, and benchmarking performance
- Development of sustainability appraisal techniques for remedy selection
- Developing an enhanced ability to apply integrated or combined approaches for complex contamination problems
- Developing an integrated approach to the planning, investigation, remediation and aftercare phases of contaminated land management
- Documenting long-term performance of pathway/ exposure control technologies
- Determining endpoints for remediation related to soil functionality.

"EURODEMO"

Following on from the conclusions of WG7, in late 2001 a number of European organisations[13] with interests in contaminated land demonstration projects met at DEFRA in London to discuss the possibilities for collaboration. The meeting concluded that there is a reluctance to accept demonstration project outputs across

[13] BRGM, France; CLAIRE, UK; exSite, UK; Nordsoil, Nordic countries; NTUA, Greece; OVAM, Belgium; SKB, Netherlands; VEGAS, Germany

national frontiers. There can be regulatory reluctance to try new techniques and technologies in the field, particularly where there are *in situ* approaches, on the basis of data from other countries. Despite a large number of demonstration and field scale research in Europe, knowledge transfer remains limited, hence there tends to be a dominance of more easily available US information. The logistics of carrying out demonstration projects vary not only from member State to member State, but can also vary from local area to local area.

The meeting identified a number of opportunities for European added value in co-ordinating the demonstration of contaminated land technologies and techniques across the Member States with DG Research and with each other. CL:AIRE co-ordinated a proposal to the EC to set up a European platform for the demonstration of technologies and techniques for managing contaminated land (soil and water). The objective of this work would be to give European business (problem holders and solution providers) and European regulators the same or better opportunities for demonstration as already exist for North American organisations. It would also:

- facilitate the uptake of pre-treatment technologies for contaminated soil required under the Landfill Directive.
- support the development of integrated strategies for river basin improvement under the Water Framework Directive.
- support the development of a European dimension in soil policy
- enhance the value of existing facilities in individual member States and hence reinforce European ability to transfer fundamental research to the field
- provide a platform for collaborating on common minimum requirements for demonstration projects, in particular relating to performance verification and quality of science.
- extend the “reach” of technology developers in Europe by (a) providing access to a wider range of ground and climate conditions than in their home country and (b) providing a minimum standard for demonstration projects to enable the easier use of results across national frontiers.
- provide knowledge transfer from countries with an extensive experience of demonstration projects to countries with an emerging or developing interest, to reduce the time and cost of establishing their own demonstration project work, and to allow a common, high, standard of demonstration project proposals to DG research and EC LIFE programmes.
- provide a platform for co-ordination to avoid duplication of effort and to liaise with existing knowledge transfer projects (for example Image-Train – see below).

6 Other International Networking Initiatives

Although CLARINET has now completed its work, a number of international networks continue to support research and development and best practice in contaminated land and groundwater management.

The *Ad Hoc* Working Group on Contaminated Land

The Ad Hoc Group is an informal coalition of professionals from regulatory agencies and government departments with responsibilities for contaminated land management. It meets every two years and has a secretariat that rotates from country to country. Approximately every two years it surveys contaminated land policy developments across the participating countries. Meetings tend to be only open to government representatives. Further information about the Ad Hoc Group is available on its web site: *www.adhocgroup.ch/.*

ANCORE

ANCORE, the Academic Network on Contaminated Land Research in Europe (ANCORE) was inaugurated by the Centre for Applied Geoscience at the University of Tübingen. ANCORE includes currently more than 60 research institutes from 16 European countries and covers a broad range of scientific disciplines involved in the field of contaminated land and groundwater research. Further information is available from *www.ancore.org*.

CABERNET

The Concerted Action on Brownfield and Economic Regeneration Network (CABERNET) was established in January 2002. It is a multidisciplinary expert network that aims to facilitate new practical solutions for urban brownfields. Its vision is to: 'Enhance rehabilitation of brownfield sites, within the context of sustainable development of European cities, by the provision of an intellectual framework for co-ordinated research and development of tools. CABERNET is a 3-year initiative, co-ordinated by the University of Nottingham in association with the German Environment Agency (Umweltbundesamt), funded under the EC 5th Framework programme .The network consists of 49 Members and 6 Co-ordination Team members originating from 21 countries across Europe. The network is focusing on four key objectives: (i) improving awareness and enhancing understanding across the professional disciplines; (ii) developing a conceptual model for brownfield issues; (iii) identifying research gaps and proposing co-ordinated research activities; and (iv) identifying best practice for practitioners. For further information visit www.cabernet.org.uk

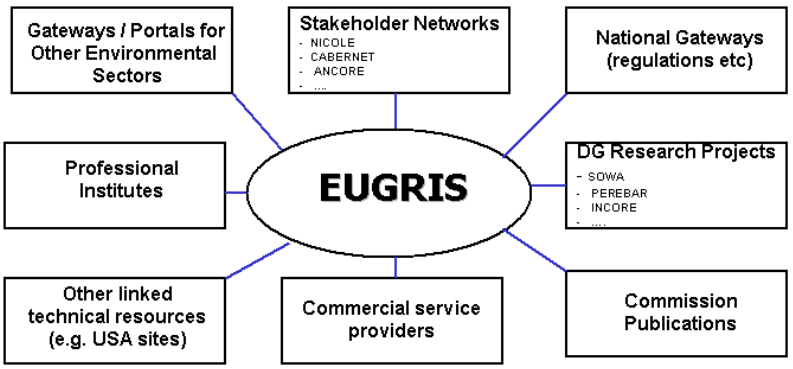
Common Forum

The Common Forum is an expert group of national and regional regulators from the EU Member States, Accession States and EFTA[14] Countries, specialised in contaminated land management. The goals of the Common Forum are:

- being a platform for the exchange of knowledge and experience,
- establishing a "discussion platform" on policy, research, technical and managerial concepts of contaminated land,
- being a forum for initiating international projects among members
- acting as a "sparring partner" to the European Commission
- acting as a "sparring partner" to the European contaminated land networks.

EUGRIS

EUGRIS is a 2.5 year Accompanying Measure that aims to develop a web based and user friendly information platform for soil and groundwater management. EUGRIS will be funded under Key Action 1 of the Fifth Framework Research Programme of the European Commission. This information gateway will be openly available and provide a comprehensive and overarching information resource for sustainable groundwater and land management practice. The co-ordination will be with the Federal Environmental Agency of Germany. The core objective of EUGRIS is the development of a fully functioning "pilot" version. It will be based on information provided by" Pilot Countries" (United Kingdom, Denmark, France, Hungary and Germany), information provided by EC projects, Concerted Actions and other international activities and initiatives.



Information from the pilot countries will be provided by the partners of the project. They represent a mixture of experienced regulating and researching governmental organisations, one university and a number of SME's from the pilot countries. EUGRIS will be designed to cater for a range of users from researchers seeking advanced information on specific topics to general enquiries from those seeking a basic level of easy to digest information. EUGRIS will furnish an easy route of access to knowledge about contaminated land and groundwater issues for all stakeholders, and so improve the general efficiency of information use in a wider

[14] European Free Trade Area

Europe. EUGRIS will further assist those synthesising and integrating the results of successful past and ongoing RTD projects and their implementation into policy approaches across Europe, as well as servicing future and current RTD. EUGRIS is expected to start at the beginning of 2003. A web link will be available from February 2003 on *www.eugris.org.*

Image-Train

Image-Train is an Accompanying Measure supporting cost-effective and eco-efficient remediation techniques for groundwater resources in Europe. It is a cluster of three current FP5 projects (INCORE, PIRAMID and PEREBAR) and focuses in particular on training young scientists. It integrates the results and innovation delivered by EC funded research projects, specifically those concerning passive *in situ* techniques for groundwater remediation approaches. One major focus of this project is dedicated to efficient knowledge and information transfer towards the European scientific community and potential end-users, and includes also a particular emphasis on the specific situation in EU Accession Countries. Among its meetings will be three Advanced Study courses for academics and young scientists.. Public access to the derived results and information within Image-Train will be provided via a web page, reports, newsletters, and technical/scientific workshops. The main objectives of Image-Train are to combine innovative research projects and available knowledge supplied by EU funded RTD projects and shorten their transfer towards practical application for needed problem solving and to transfer existing and emerging knowledge to young scientists and academics in the European Union and the EU Accession Countries. All IMAGE-TRAIN products (newsletter, proceedings, summary reports and other) can be directly downloaded from the project's website: *http://www.image-trian.net/*.

NATO/CCMS Pilot Study - Evaluation of Demonstrated and Emerging Technologies for the Treatment and Cleanup of Contaminated land and Groundwater

This recent pilot study is led by the United States with Germany and the Netherlands as co-pilot countries. The intent of these meetings is to freely exchange information and experiences among remediation experts from various countries. The goal is for each country to go away from each meeting having increased their knowledge in the remediation field. Since these meetings have started, this goal has been met. Information from the pilot study is placed on NATO (www.nato.int/ccms/home.htm) and EPA (www.clu-in.org/partner1.cfm) web sites. Each meeting consists of four principal parts: 1) the technical session addressing a specific topic, 2) the country updates on regulatory and environmental issues, 3) the field trip, and 4) the discussion of projects associated with the pilot study. An annual meeting report and technical session report are produced after each meeting. These reports are placed on the above web sites. A further phases of the Pilot Study has just been agreed. For more information visit *www.nato.int/ccms*

NICOLE

NICOLE (Network for Contaminated Land in Europe) was set up in 1995 as a result of the CEFIC "SUSTECH" programme which promotes co-operation between industry and academia on the development of sustainable technologies. NICOLE is the principal forum that European business uses to develop and influence the state of the art in contaminated land management in Europe. NICOLE was created to bring together problem holders and researchers throughout Europe who are interested in all aspects of contaminated land. It is open to public and private sector organisations. NICOLE was initiated as a Concerted Action within the European Commission's Environment and Climate RTD Programme in 1996. It has been self-funding since February 1999. NICOLE's overall objectives are to:

- Provide a European forum for the dissemination and exchange of knowledge and ideas about contaminated land arising from industrial and commercial activities;
- Identify research needs and promote collaborative research that will enable European industry to identify, assess and manage contaminated sites more efficiently and cost-effectively; and
- Collaborate with other international networks inside and outside Europe and encompass the views of a wide a range of interest groups and stakeholders (for example, land developers, local/regional authorities and the insurance/financial investment community).

NICOLE currently has 160 members. Membership fees are used to support and further the aims of the network, including: technical exchanges, network conferences, special interest meetings, brokerage of research and research contacts and information dissemination via a web site, newsletter and journal publications. NICOLE includes an Industry Subgroup (ISG) – with 27 members; a Service Providers Subgroup (SPG) with 32 members; 85 individual members from the academic sector/research community; and 16 members from other organisations, including research planners, non-profit making organisations, other networks, funding organisations. Some members are involved in both the ISG and the SPG. For further general information, further meeting reports, network information and links to contaminated land related web sites, please visit NICOLE's web site: *www.nicole.org*

Permeable Reactive Barrier Network

The Permeable Reactive Barrier Network (PRB-Net) held its first workshop during 25th – 27th April, 2001, focussing on PRB technology and its current international status. This workshop included a field trip to two reactive barrier sites in N. Ireland: a Zero Valent Iron reactor and a biological PRB (both firsts in Europe). The workshop attracted delegates from 13 different countries, including the USA, Canada, Germany, Belgium, France, the Netherlands, and Korea. A number of other workshops and an International Conference on Reactive Barriers / Zones are planned for the next 2½ years, serving to disseminate information to the wider community and facilitate communication between inter-disciplinary groups. Further details can be found at *www.prb-net.org*.

REC

The Regional Environmental Centre for Central and Eastern Europe (REC) is an international, diplomatic status organisation with a mission to assist sustainable development and coping environmental challenges in Central and Eastern Europe (CEE). The REC fulfils its mission through encouraging cooperation among governments and businesses and NGOs, supporting the information exchange and promoting cross-sectoral (or multi-stakeholder participation and dialogue in environmental planning and decision making. The REC was established by the Governments of Hungary, United States and European Commission in 1990, and it is legally based on a Charter signed by 28 countries so far. RECs main donors include the European Commission, the governments of the United States, Japan, Canada, the Netherlands, UK, Denmark, Austria, Germany, Hungary, Czech Republic, Slovakia, Croatia, as well as other intergovernmental and private institutions. For further information view *www.rec.org*

RESCUE

RESCUE (Regeneration of European Sites in Cities and Urban Environments) is a research project in the framework of key action IV "Cities of tomorrow and cultural heritage" within the 5th Framework Programme of the European Community. Started in March 2002, RESCUE is a 36-month research project integrating the concept of sustainability into brownfield regeneration. Based on the analysis and evaluation of current practice in industrial core regions in France (Nord-Pas de Calais), United Kingdom (Derbyshire, North-East of England), Poland (Silesia) and Germany (Ruhr Area, Southern District of Leipzig), RESCUE distils best practice approaches at reduced costs and integrates its results into a holistic system approach containing new methodologies, procedures and instruments for a sustainable regeneration of European industrial brownfield sites. The regeneration process will be broken down into the main steps of decision making and analysed along transnational work packages by interdisciplinary teams. For further information visit *www.rescue-europe.com*

SedNet

The SedNet mission is to be a European network for environmentally, socially and economically viable practices of sediment management on river basin scales. Due to the trans-boundary nature, no single water manager or country has the responsibility for solving sediment management problems at such scale. SedNet is established to help to structure and facilitate a European approach on this issue. SedNet is funded for 3 years as a Thematic Network project by the European Union under FP5 (Contract No. EVK1-CT-2001-20002, starting date: 1 January 2002). Its Inaugural Conference was held at 22 & 23 April 2002 at the SedNet home base at San Servolo Island, Venice, Italy. More than 120 sediment experts from 18 countries visited the conference. For further information visit *www.SedNet.org*

SENSPOL

The EC Environment and Sustainable Development Programme's network SENSPOL focuses on 'Sensors for Monitoring Water Pollution from Contaminated Land, Landfills and Sediment'. SENSPOL provides a route to identify environmental monitoring requirements and proposed solutions; its website address is www.cranfield.ac.uk/biotech/senspol.htm For further information visit: *www.cranfield.ac.uk/biotech/senspol.htm.*

7 CLARINET Benefits for the UK

The UK made a major contribution through DEFRA, and its contractors, and the Environment Agency to CLARINET, with further voluntary involvement from 15 individual experts. UK expertise has both influenced, and been influenced by participation in CLARINET. The major assets from CLARINET have been the written reports (available from www.clarinet.at), a number of further networking initiatives and projects, but most important of all a developing European consensus on the use of risk management and sustainable development as decision making disciplines for contaminated land and groundwater. CLARINET's outputs have been made widely available via the Internet and technical journals, as well as via an open conference in 2001 in Vienna and an open meeting in Nottingham during March 2002[15]. Information from CLARINET was highly regarded by those surveyed in the recent DEFRA audit of contaminated land research[16].

CLARINET played a major role in delivering consensus across Europe on risk-based land management related to land-use. As late as 1997 multi-functionality was formally adopted in the Netherlands. Perhaps some UK pragmatism has been of assistance in delivering this consensus. Certainly the UK has provided a high level of support both for CLARINET and its predecessor, CARACAS. This consensus has been able to influence important new EC legislation relating to environmental liabilities and has been helpful in marshalling opinion against generic standards for groundwater quality in the Groundwater Daughter Directive.

Another benefit from CLARINET is the development and consolidation of a diverse range of networks of experts/policymakers across Europe, with increasing opportunities for participation.

CLARINET also played a major role in the promotion and inspiration of contaminated land related R&D project proposals for the EC Framework 5 Programme[17], which has

[15] This section is in part based on discussions at the 4th March 2002 meeting

[16] Wood, P., Spencer, P. and Macnaughton, S. (2002) Audit of Contaminated Land, Research in the UK, DEFRA, UK, www.defra.gov.uk

[17] Both FP5 and FP6 are described on www.cordis.lu

now been succeeded by the Framework 6 Programme (FP5 and FP6). FP5 made available a large amount of funding for work connected with groundwater protection, and brownfield site redevelopment. CLARINET maintained contact with more than 200 scientists and stakeholders in contaminated land management in Europe. It collected over 100 outline proposals and ideas for the first call to the Framework 5 programme alone, and circulated these proposals to its membership to solicit their interest. CLARINET also produced a number of documents with R&D suggestions and priorities (in association with other European networks such as NICOLE, to guide the scientific community.

However, there are also some lessons that can be learnt for future UK involvement in contaminated land networks. Accessibility of information, and the openness of CLARINET to participation has been seen as limited by some. For example, there might have been benefit from including a greater role for local authorities in CLARINET (and other international networks). Reporting CLARINET events could have been more frequent, and more widely promoted.

These limitations have been to some extent unavoidable. It was not practical to operate the European "plenum" meetings of CLARINET as open conferences. The collation of information was limited by its reliance on the voluntary effort of many, and simply the time taken for texts to be agreed by international panels. Given that the finalisation of CLARINET documents took place over 2001, it was not possible to deliver crisp outputs to UK meetings over the course of the Concerted Action. Nonetheless, through the network of nominees the UK was able to deliver a good level of peer review of the CLARINET work. Perhaps the recent publication of the final CLARINET outputs is an opportunity that UK contaminated land conference organisers can take advantage of.

Some at the Nottingham meeting felt that the European networking on contaminated land was restricted to those from the academic, regulatory and policy sectors. While this may be true of some networks such as the Common Forum, there are many networks, listed in the Section above, which have open participation and which would welcome new members. For example, NICOLE is actively seeking local authority and financial sector members. To a large degree, if an individual or organisation wants to get involved with one of these networks, it is up to them to get in touch, for example via the network's web site.

8 CLARINET's Own Conclusions

CLARINET's own conclusions were centred on Risk Based Land Management. CLARINET concluded that to put the RBLM concept into practice, action needs to take place on three main fronts:

- in continued research to improve the knowledge base and develop tools to support the emerging areas of European policy which are affected by contaminated land;
- in improving practice by the transfer of knowledge and information to a range of groups; and
- in integration of policy approaches.

The RBLM concept and its relevance for sustainable management of soil and water resources are currently being discussed at a European and - in some cases – national level, for example, by the Common Forum and with regard to future EU regulations, such as the Water Framework Directive and possible "Daughter-Directive" on groundwater, the EU Soil Policy, the Environmental Liability Directive and FP6.

Environmental priority setting for policymaking and regulation has often considered water and air before land. Land issues - such as contamination, land use, soil protection and waste disposal - are still considered in different compartments and, to some extent as a result, as a series of ad hoc problems. Technical solutions have often addressed a narrow perspective; in particular, the long-term value of the land as an environmental resource or the wider impacts of particular technologies have not been considered.

As experience has shown in other environmental fields, a narrow problem-oriented approach will not automatically lead to a sustainable use of environmental resources. The total environment, including soil and water, has to be managed in a sustainable way.

Better decisions about the solutions of contaminated land problems can be made if there is clear interaction and integration of the management of contaminated land, of land use planning, and of wider environmental protection controls, which of course must include waste management.

The Risk Based Land Management concept of the CLARINET Concerted Action is intended to be a step forward towards an integration of sustainable soil quality, protection of water and land use management in environmental policy.

CLARINET's vision is to see a change in social and political attitudes away from a negative perception of contaminated land towards that of positive shared action to conserve and enhance the soil and water resources.

9 General Conclusions

CLARINET has been a successful EC project that has drawn on scientists and other experts from 16 countries in Europe to advance the state of the art in contaminated land management. A wide range of publications have been produced, which are available on it's web site (*www.clarinet.at*), including:

- Its overall findings: "Sustainable Management of, Contaminated Land: an Overview".
- Working Groups reports
    - Brownfields and Redevelopment of Urban Areas (WG1)
    - Review of Decision Support Tools for Contaminated Land Management and their use in Europe (WG2)
    - Contaminated Land and its Impact on Water Resources (WG3)
    - An Analysis of National and EU RTD Programmes related to sustainable Land and Groundwater Management (WG4)
    - Remediation of Contaminated Land. Technology Implementation in Europe -
    - State-of-the-Art (WG7)

In addition, CLARINET stimulated a number of "Satellite" Publications:

- Proceedings of the CLARINET Workshop on Ecological Risk Assessment, April 17-19, 2001 Nunspeet, The Netherlands. S-TEC 2001
- Environment Agency for England and Wales, June 2001: Epidemiology Workshop on Human Health Tools and Techniques - Report; Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4DU
- *Land Contamination & Reclamation*, Special Issue Vol. Nine - Number One, 2001; published by EPP Publications, 52 Kings Road, Richmond, Surrey TW10 6EP, UK
- Frank Swartjes, 2002: Variation in calculated human exposure: Comparison of
- calculations with seven European human exposure models (in press) - RIVM
- report 711701030; Amsterdam 2002.

CLARINET developed the concept of *Risk Based Land Management (RBLM)* as a step forward towards an integration of sustainable soil quality, protection of water and land use management in environmental policy. The aim of the RBLM is to achieve the integration of approaches originating from different perspectives (for example spatial planning, environmental protection and engineering), based on the identification of common goals:

- Comparable levels of protection of health and the environment, taking into account local characteristics;
- Optimised use and development of technical and administrative solutions; and
- Sustainability - evaluating and optimising environmental, economic and social factors

The concept applies at different scales – site, regional, national – and covers the whole cycle of risk assessment and risk management of contaminated land. It is

driven by current and emerging scientific knowledge. It links to wider themes, in particular to soil protection, spatial planning, and water catchment management.

The concept also applies at a strategic level. However, it has practical application at a site specific level: the operational details of treatment, monitoring, aftercare and other risk management techniques (containment techniques for instance) can be assessed using the RBLM concept on a site-specific basis.

The UK, through DEFRA and the Environment Agency, has been a major supporter of CLARINET. Through this support the UK has been influential in CLARINET's many successes, in particular that CLARINET played a major role in delivering consensus across Europe on risk-based land management related to land-use. This consensus has been able to influence important new EC legislation relating to environmental liabilities and has been helpful in marshalling opinion against generic standards for groundwater quality in the Groundwater Daughter Directive. This support has also assisted the participation of a number of UK organisations in FP5 projects.

Annex 1 CLL 35/1/12 Deliverables

Note: papers marked (*) were also co-funded from other sources

* A Review of the Contaminated Land Rehabilitation Network For Environmental Technologies in Europe (CLARINET). Part 2: Working Group Findings, Submitted for publication in *Land Contamination and Reclamation*

* Bardos, P., Vik, E., Brogan, P., Edwards, D., Gondi, F., Henrysson, T., Jensen, K., Jorge, C., Mariotti,C., Nathanail, P., and Papassiopi N. (2001) Towards a Framework for Selecting Remediation Technologies for Contaminated Sites. Presented at yhe EU ETCA Workshop on the *Protection of European Water Resources*. Harrogate, England, 21st to 23rd May 2001, Harrogate, UK.

* Bardos, R., P., Mariotti, C., Marot, F., Nortcliff, S., Sullivan, T., and Lewis, A. (2001) Review of Decision Support Tools and their use in Europe. Report of CLARINET Working Group 2. In preparation, will be available from www.clarinet.at

* Bardos, R.P, Mariotti C., and Nortcliff, S. (2000) A Framework and Categorisation of Decision Support Systems used in Contaminated Land Management across Europe (CLARINET Countries) Pages 169-170 in Contaminated Soil 2000. Proc 7th Intern FZK/TNO Conf on Contaminated Soil 18-22 September 2000, Leipzig, Germany.

* Bardos, R.P. (2002) A Framework for Remedy Selection. Presented at Contaminated Land Management. London, February 18-19 2002. IBC Global Conferences Ltd, Gilmoora House, 57-61 Mortimer Street, London W1N 8JX. UK.

* Bardos, R.P. and Lewis, A.J. (2001) CLARINET and NICOLE Special Edition, The Sustainable Management and Remediation of Contaminated Land. *Land Contamination and Reclamation* **9** (1) 47-174

* Bardos, R.P. and Vik, E. (2001) Decision Making for the Remediation of Contaminated Sites. Presented at the ICS-UNIDO Expert Group Meeting on "Remediation of Polluted Sites in CEE Countries, Current Status and Perspectives

* Bardos, R.P. and Vik, E. (2001) A Framework for Selecting Remediation Technologies for Contaminated Sites. Proceedings of the CLARINET Final Conference, Vienna, 21-22 June 2001. Available from www.clarinet.at

* Bardos, R.P. and Vik, E. (2001) Summary of clarinet's key findings on risk management solutions and decision support in Europe. Proceedings of the CLARINET Final Conference, Vienna, 21-22 June 2001. Available from www.clarinet.at

* Bardos, R.P., Lewis, A. J., Nortcliff, S., Mariotti, C., Marot, F. and Sullivan, T. (2002) Review of Decision Support Tools for Contaminated Land Management, and their use in Europe. Final Report. Austrian Federal Environment Agency, 2002 on behalf of CLARINET, Spittelauer Lände 5, A-1090 Wien, Austria. Available from: *www.clarinet.at*

* Bardos, R.P., Mariotti, C., Marot, F. and Sullivan, T. (2000) Decision Support for Contaminated Land in Europe and North America (Outputs from CLARINET and the NATO/CCMS Pilot Study on Remedial Action Technologies for Contaminated Soil and Groundwater) Pages 337-344 in Contaminated Soil 2000. Proc 7th Intern FZK/TNO Conf on Contaminated Soil 18-22 September 2000, Leipzig, Germany.

* Bardos, R.P.; Mariotti, C.; Marot, F.; and Sullivan, T. (2000) Framework For Decision Support Used In Contaminated Land Management In Europe And North America. pp 9-30 IN the NATO Committee on Challenges to Modern Society: NATO/CCMS Pilot Study Evaluation of Demonstrated and Emerging Technologies for the Treatment and Clean Up of Contaminated Land and Groundwater. Phase III 2000 Special Session Decision Support. NATO/CCMS Report No 245. EPA Report: 542-R-00-011

* Bardos, R.P.; Mariotti, C.; Marot, F.; and Sullivan, T. (2001) Framework For Decision Support Used In Contaminated Land Management In Europe And North America. *Land Contamination and Reclamation* **9** (1) 149-163

* Kasamas, H. and Bardos, R.P. (2001) International Networks on Contaminated Land. *Land Contamination and Reclamation* **9** (1) 170-171

* On line decision support tool catalogue www.r3environmental.co.uk/dstdemo

* Posters were also prepared for the CLARINET Final Conference (C*lassifying Available Remediation Techniques, Survey Of Decision Support For Contaminated Site Management Across European Countries, Framework for Decision Support used in Contaminated Land Management in Europe and North America, and CLARINET On Line Catalogue of Decision Support Tools*)

* Vik E. A. et al (2001): Remediation of Contaminated Land Technology Implementation in Europe. A state-of-the-art review. Final Report of CLARINET WG7.

* Vik, E.A., Bardos R.P., Brogan, J. Edwards, D. Gondi, F. Henrysson T., Jensen B.K., Jorge C., Mariotti C., Nathanail P., Papassiopi N. (2001) Towards a Framework for Selecting Remediation Technologies for Contaminated Sites. *Land Contamination and Reclamation* **9** (1) 119-127

*[Bardos, R.P. (1999) A Summary of the UK's Participation in CLARINET and the NATO/CCMS Pilot Study during 1998 and 1999. Environment Agency R&D Technical Report P321. Available from: Environment Agency R&D Dissemination Centre, c/o WRC, Frankland Road, Swindon, Wilts SNF 8YF.]

A Review of the Contaminated Land Rehabilitation Network For Environmental Technologies in Europe (CLARINET). Part 1 Risk-Based Land Management - A Concept for the Sustainable Management of Contaminated Land, Submitted for publication in *Land Contamination and Reclamation*

Bardos, P. (2000) UK Participation in CLARINET. The Contaminated Land Rehabilitation Network for Environmental Technologies in Europe. *Wastes Management* November 2000, 22-25.

Bardos, P., Lowe, M. and Baverstock, A. (1999) UK Participation in CLARINET: The Contaminated Land Rehabilitation Network for Environmental Technologies. *Land Contamination and Reclamation* 4 (4) 237-243

Bardos, R.P., Nathanail, J. and Pope, B. (2002) General Principles for Remedial Approach Selection. *Land Contamination and Reclamation* **10** (3) 137-160

CLARINET article in *CLAIRE News October 2000*

CLARINET Information Papers 2000 and 2001 versions

CLARINET slide set for use in the UK

Draft EURODEMO workshop report (December 2001)

Project Technical Summaries 1999 and 2002 versions

Annex 2: European Research Programmes Related to Contaminated Land and Groundwater Management (2001)

	Title of research programme	**Managed by**	**WWW information**
Austria	Support of studies and R&D projects for remediation of contaminated sites	Kommunalkredit Austria AG Environmental support	www.kommunalkredit.at www.kommunalkredit.at/altlasten/F_E-Projekte/f_e-projekte.htm *(English version)*
Belgium	OVAM R&D programme	OVAM Dienst Sanering	www.ovam.be www.ovam.be/english/multilang.asp *(English version)*
Denmark	The Danish EPA's technology programme for soil and groundwater contamination Various programmes	Danish EPA. Cross-ministerial programme. Strategic Environmental Research Programme. Danish Ministry for trade and Industry.	www.mst.dk/homepage/ *(English version)* www.dmu.dk/1_english/default.asp *(English version)* www.smp.aau.dk (*English version)* www.biopro.dk (*English version)* www.dhi.dk www.imt.dtu.dk (*English version)* www.GEUS.dk
Finland	Various programmes	Various institutions	www.vyh.fi/eng/fei/fei/html *(English version)* www.vyh.fi/eng/research/r%5Fdprog/r_dprog.htm *(English version)*
France	Various programmes	Ministry MATE and ADEME	www.environnement.gouv.fr/english/default.htm *(English version)* www.ademe.fr/anglais/vadefault.htm *(English version)*
Germany	National R&D programme of the federal Administration "Research for the	Ministry BMBF	www.bmbf.de/ *(in German)* www.umweltbundesamt.de/index-e.htm *(English version)*

	Environment" (Forschung für die Umwelt)		
Greece	No national R&D programme, but various relevant projects	Ministries of Development and Agriculture and Environment	www.gsrt.gr www.minenv.gr (*in Greek*)
Italy	Various programmes, not specific for contaminated land issues	Mainly Ministry for Scientific Research, Ministry for Environment, Italian ANPA and National Research Council	www.minambiente.it *(in Italian)* www.sinanet.anpa.it *(in Italian)* www.idg.fi.cnr.it/homeeng.htm *(English version)* http://www.murst.it (in italian)/
Netherlands	Centre for soil quality management and knowledge transfer	SKB	www.bodembreed.nl *(in Dutch)*
Norway	Pollutants: Sources, dispersal and effects "ProFo"	The Research Council of Norway	www.forskningsradet.no/english *(English version)*
United Kingdom	A variety of relevant programmes though none are dedicated solely to contaminated land issues, e.g. LINK Biological Treatment of Soil and water programme. CLAIRE network of contaminated land sites – a public/private partnership	Three research councils, three Environmental agencies and three Ministries (includes 7 regional development agencies)	www.bbsrc.ac.uk www.epsrc.ac.uk/programmes www.nerc.ac.uk www.environment-agency.gov.uk www.sepa.org.uk www.ehsni.gov.uk www.defra.gov.uk www.dti.gov.uk www.scotland.gov.uk/who/dept_rural.asp www.claire.co.uk
EU	Fifth Framework Programme Theme: Environment and sustainable development	DG Research (D1.2) Key action: Sustainable Management and quality of water	www.cordis.lu/eesd/src/overview.htm#3 europa.eu.int/comm/research/fp5.html www.cordis.lu/fp5/home.html *(in all languages)*