CLARINET

Sustainable Management of Contaminated Land: An Overview

A report from the Contaminated Land Rehabilitation Network for Environmental Technologies

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SUSTAINABLE MANAGEMENT OF CONTAMINATED LAND: AN OVERVIEW

Report prepared by the Concerted Action "Contaminated Land Rehabilitation Network for Environmental Technologies" (CLARINET), funded by the European Commission, DG Research, under the Environment and Climate Programme and co-ordinated by the Austrian Federal Environment Agency.

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- Remediation of Contaminated Land. Technology Implementation in Europe - State-of-the-Art
- Review of Decision Support Tools and their use in Europe
- An Analysis of National and EU RTD Programmes related to sustainable Land and Groundwater Management
- Clarinet Final Conference, Proceedings; 21/22 June 2001, Vienna, Austria

CLARINET 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, 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 - RIVM report 711701030; Amsterdam 2002

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Members of CLARINET would also like to acknowledge the personal and intellectual contribution made by the late Professor Colin Ferguson to this network.

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FOREWORD

In this report, we present an overview of the work of the Contaminated Land Rehabilitation Network for Environmental Technologies (CLARINET) project – a Concerted Action funded under the 4th Framework Research, Technology and Development Programme of the European Commission is presented.

The report describes the background to the CLARINET work and presents the concept of “risk based land management” or “RBLM”. We have developed this concept 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 during the CLARINET work in the context of the risk based land management concept. More detailed technical publications are available on this work - references are provided at the end of each chapter.

Although we have based the CLARINET work on information exchanges and joint activities within member states of the European Union, we have tried to address topics that are also of relevance to other countries, in particular those in Central and Eastern Europe.

We hope that the report will be of interest to 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.

Martin Schamann
Federal Environment Agency, Austria
On behalf of the CLARINET Steering Committee and members of the network.

THE WORK OF CLARINET

CLARINET has been a concerted action on contaminated land funded under the European Commission 4th Framework Programme for Research and Technological Development, with member states also supporting participation and funding specific projects and activities.

CLARINET developed as part of a wider history of emerging collaboration and international exchange on contaminated land. In particular it builds on the work of CARACAS and has links with other networks and organisations, such as NICOLE (Network for Industrially Contaminated Land in Europe), NATO/CCMS Pilot studies, Ad Hoc International Working Group on Contaminated Land, EU Common Forum on Contaminated Land, EC DG Research, European Environment Agency, US-EPA and many others.

The overall aim of CLARINET has been to identify efficient ways to deal with contaminated land without compromising public health and water quality, business confidence in the benefits of land regeneration, or the sustainable use of land. The objectives have been to:

- Improve the technical and scientific basis to focus on research and technical development (RTD) needs
- Use available knowledge and expertise to make recommendations to national and EC decision makers
- Promote interaction between policy, practice and scientific knowledge
- Focus on problem solving
- Improve common practice and implement existing knowledge

As a focussed network, it has promoted partnership between the EC and member states, between the 20 or more countries who send representatives and between many different stakeholders (including Government Ministries and Agencies, industry, and scientists). It is multidisciplinary and has aimed to be a catalyst between different perspectives. It has contributed to continuing research and technological development programmes both under the EC 5th Framework Programme and beyond, and at national level.

CLARINET OUTPUTS AND INFORMATION EXCHANGE

CLARINET has concentrated its work on a number of key areas of relevance to find solutions to contaminated land problems. Working groups have covered:

- Impact of contaminated land on water resources
- Brownfield redevelopment
- Human health
- Ecological health related to land uses and functions
- Remediation technologies and techniques
- Decision support
- Collaboration of R&D programmes in Europe.

All of these groups have produced specific outputs and there are a number of other general or collective outputs from CLARINET, including published papers, conference reports, information leaflets, and statements. A list of these is in Annex II.

This report presents the concept of “risk based land management” or “RBLM”. This concept 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 during the CLARINET work in the context of the risk based land management concept.

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CHAPTER 1 CONTAMINATED LAND

A present from the past

The topic of contaminated land has been an increasingly important one in many areas of policy, research and practice both within different countries and at international level. This section summarises the context for this increasing interest, the background to CLARINET and its work to address key issues at a European level.

In this report, *contaminated land*[1] is a general term to describe sites, and wider areas of *land*, which have elevated concentrations of chemicals or other substances (*contamination*), usually resulting from man's use of the land. The report focuses on contamination resulting from past practices - historic (past) or *legacy (inherited) contamination*[2].

Legacy contamination is a key category of land contamination. There are two main reasons. First, the persistent nature of contamination in soil or groundwater means that problems can occur now, or might occur in the future, as a result of actions which took place many years ago. Secondly, problems from legacy contamination are often more difficult to manage than contamination which might result from new activities. Past practices often failed to recognize their impact on the *environment*, which has resulted in complex and widespread contamination in soil and groundwater. Because of the lack of knowledge of the existence of the contamination and its effects, this past contamination may now have spread over large distances underground, and may be difficult to characterise.

Contamination can be of many different types, ranging from one substance to many, and from simple chemical substances to complex ones. The contamination may also range widely in concentration. It can include biological contaminants, such as pathogens, and radiological contamination. (The focus of the CLARINET work has been on chemical contamination. Although many of the principles are common, CLARINET has not specifically addressed biological, nuclear or radioactive contamination, contamination from complex military activities, ***diffuse***[3] *contamination*, or the generation of methane from domestic waste disposal sites. Proceedings of

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[1] Terms written in italics are explained in the glossary.

[2] Many countries treat the management of new, or **future contamination**, that is contamination caused by current practices, in a different way to the management of **legacy contamination**. The legal and technical requirements for prevention of new contamination are often more stringent, both as an incentive to prevent new contamination and as a reflection of the expected ability to prevent it. (It applies the **preventive principle** – see later). However, the overall science of risk assessment and risk management can also apply to contamination caused by recent activities.

[3] "Diffuse" contamination describes large geographical areas where the contamination is widespread, for example from agricultural practices or airborne deposition.

regular international workshops and conferences such as CONSOIL [1], NATO/CCMS [2], IHPA [3], IAEA [4], ISWA [5] etc. provide a source of additional specialist information on these topics.

The contamination may cover a large spatial area for example, where there were large industrial complexes, or where secondary spreading of pollution has occurred by wind and water or it may be confined to quite small sites where a more limited use may have taken place for example a very small area previously used for disposal of municipal waste. Awareness of the full extent of contaminated land and its diversity in European countries has increased. Although data is far from complete, it is clear that most countries have a large number of contaminated land problems [6].

The term *land* means different things in different countries[4] and has many different legal definitions. The CLARINET work regards land first as a spatial concept, so it refers for example to a geographical area, such as a site or a region. However, it also includes the physical components of this spatial area, such as *soil* and *groundwater* beneath the surface of the land *(figure 1.1).*

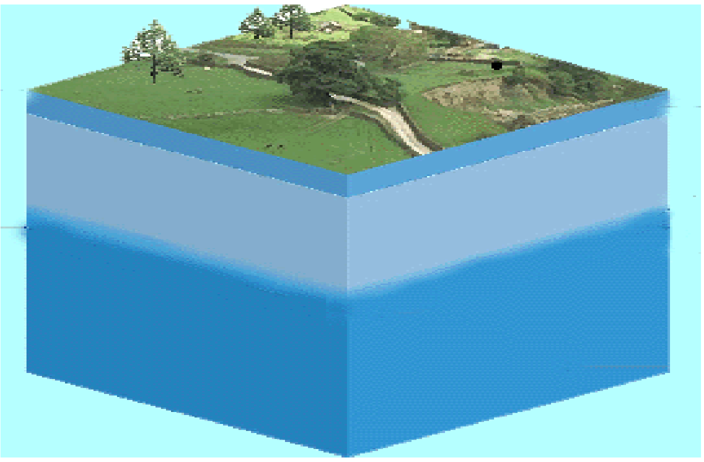

Figure 1.1: "Land" as a three dimensional spatial area[5]

Soil also has different meanings in different scientific disciplines. CLARINET uses "soil" as a general term to mean the material on the surface of underlying geological materials[6].

The boundaries between land, groundwater and surface waters are not always distinct. Groundwater contamination may also extend over a much wider area than an individual site under consideration, or may even be in a very different location if contamination occurred long ago.

These and other terms used in the CLARINET work are listed in Annex 1.

[4] Dictionary definitions of land include: "the solid portion of the earth's surface"; "the ground"; "the soil"; "a tract of country" and "property".

[5] from UK Groundwater Forum "*Groundwater: Our hidden asset*", published by the British Geological Survey

[6] This is similar to the formal definition given in ISO 11074-4:1999

1.1 Context

The extent of contaminated land in different countries and the approaches to managing the related problems have been the subject of considerable discussion and exchange of information and ideas in the last 10 or more years [6] [7] [8] [9] [10]. To some degree, all countries have inherited a legacy of contamination from previous uses of the land. Most countries have recognised the specific problems for human health and the quality of the environment, as well as the consequent economic burden.

Initially national policies for contaminated land reflect the way that the countries first perceived the problems. Recent developments in contaminated land policies, particularly in the European countries, have tended to lessen any initial differences, with the result that the policies now clearly have much in common. Risk assessment is now widely used to assess potential human health and *environmental* impacts [8] [11] [12] [13].

However, land contamination remains an important issue at a national and international level. There are a number of key factors here, in particular:

1.1.1 Different types of problems faced by different regions

Although similar industries can give rise to similar contamination, even if they are in different countries, the general industrial patterns, scale and particular histories vary between different regions. Iron and steel producing areas have traditionally shared similar problems, but these may not be the same as those, for example, in an area where timber production was the major industry. Even where the industries are similar, the effect of the contamination on the environment or on human health may be very different, because of different scale of industrial use, different legal frameworks or different geographical and hydrogeological conditions. The consequences of the *damage* for the economy or for quality of life may also vary, because of different economic or social pressures.

Solutions need to take into account these differences, but build efficiently on existing and emerging knowledge. CLARINET considered some of the specific aspects of concern, so that sharing of knowledge and innovation at a European scale could lead to an integrated scientific approach to the different problems[7].

1.1.2 The impacts of contaminated land

In environmental terms, contaminated land can have impacts on:

- Health of humans;
- Quality of surface and groundwater;
- Nature and viability of *ecosystem*s;

[7] see Chapter 7 “Towards a European Research Area”

- Condition of buildings and other materials and archaeological artefacts within the ground;
- Visual amenity of an area.

Not all of the impacts are necessarily harmful. For example, contaminated land can be home to particular ecosystems that rely on the particular contamination conditions. Some of the locations of contaminated land are part of increasingly valued industrial heritage.

These environmental impacts cause other economic and social impacts. This is not just in terms of cost of clean up, but in wider effects on the value of land and the way in which the communities on or near the land are affected.

Some of the impacts have received more attention than others in the past. As a result, tools and technologies for assessment and choice of solutions are not necessarily perfect or available to address all the emerging problems [14].

Many of the underlying scientific and technical issues are complex. For example, it is difficult to measure and predict the nature and behaviour of the soil environment and the contamination, and the way in which contamination affects people and the environment. There are also different perceptions of the significance of the impact. CARACAS[8] and CLARINET were initiated to assist in identifying solutions to address the difficulties.

1.1.3 Policy approaches

Policies traditionally often view contaminated land problems from two main perspectives. The first is the perspective of protection - relating to the impact of contamination on human health and environmental quality. The other is the spatial planning perspective - managing the impact of contaminated land on the way land is used, for example regenerating industrial areas, or increasing agriculture use, or for creating a nature area.

These different perspectives influence the different legal regimes used in different countries: some countries use environmental legislation as the primary means of preventing impacts from land contamination on land use and the environment, others use spatial planning legislation.

The major trend in policy development is to address these two aspects simultaneously *(figure 1.2)*. This is increasingly evident in the development of a more holistic approach to management of urban development. This in turn increasingly links to economic issues, such as changes to land values and use of the market to drive environmental improvements.

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[8] CARACAS – Concerted Action on Risk Assessment for Contaminated Sites in Europe: *http://www.caracas.at*

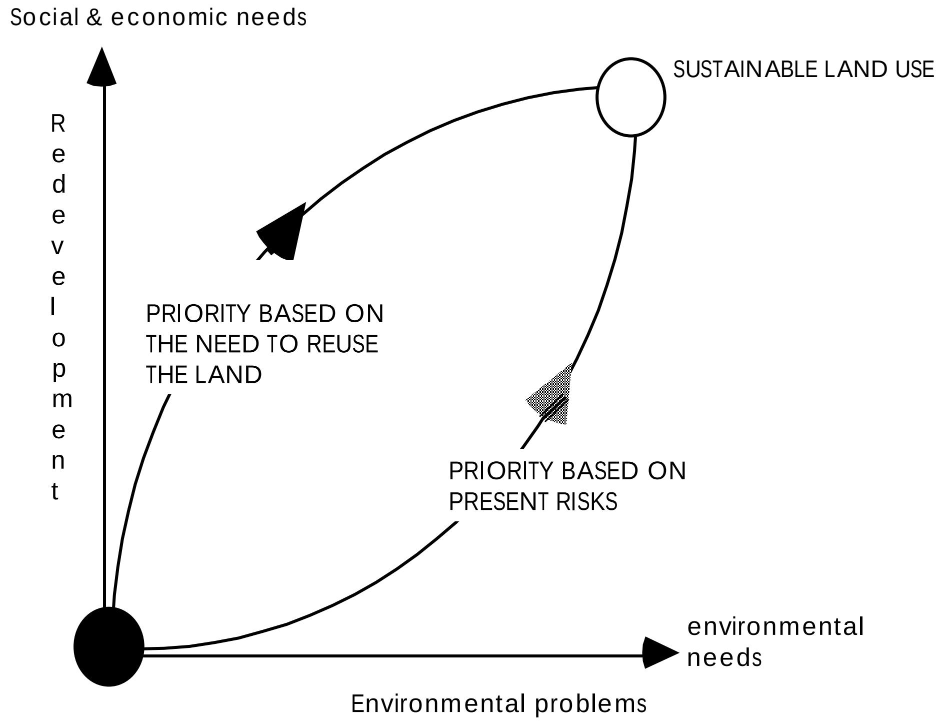

Figure 1.2: ***Trend in policy development in European countries:*** *Different drivers for solving contaminated land problems ultimately aim at restoring the capacity to reuse the land. Defining contaminated land problems as a general burden for society instead of a sectoral environmental or spatial planning problem will assist in finding sustainable solutions.*

Underlying all this is the wider perspective of *sustainable development*[9], in particular the need to consider the timing of any intervention and the future consequences of any particular solution in relation to environmental, economic, social and cultural dimensions.

1.1.4 Cross cutting themes in environmental and other policy areas

At a national and European level a number of thematic issues are emerging which overlap with the issue of contaminated land. Particularly relevant topics include:

- **Soil:** This is increasingly the focus of scientific as well as political attention. In particular, the 6th Environment Action Programme of the European Commission provides a mandate for a soil thematic strategy [16]:

[9] This concept gained international governmental recognition at the United Nation's Earth Summit conference in Rio de Janeiro in 1992. Sustainable development has been defined as: "…. *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (BRUNDTLAND, 1987) [15].

"Soil is a finite resource vital to agriculture, and is under pressure. Erosion that is climate and weather related is a particular problem in Southern Europe but increasingly also in the North. Erosion is often linked to reduced content of organic matter in soil and this can also lead to desertification. Some agricultural practices and abandonment of land are among the predisposing factors. Other threats include pollution and loss of land to development. …

… Given the complex nature of the pressures weighing on soils and the need to build a soil policy on a sound basis of data and assessment, a thematic strategy for soil protection is proposed. The EU research programmes should support this work."

The Communication on Soil Protection from DG Environment [17] includes the identification of point pollution and contaminated sites as a key issue, as well as other factors - such as soil biodiversity, soil loss and the relationship with planning policies - which may be relevant to solutions for contaminated land problems.

- **Protection of water resources:** The Water Framework Directive [18] is an important new measure at a European level. The Directive introduces integrated water management at a catchment scale. It will be necessary to consider and deal with all the influences on river water quality, which can include the quality of soil and groundwater.
- **Sustainable land management:** The EC Communication "Sustainable Urban Development in the European Union: a Framework for Action" [19] identified the presence of extensive areas of derelict land which may be contaminated as one of the main challenges for sustainable land use. Solutions to the problems of contamination are needed to enable the reuse of this type of land and help to prevent further outward urban expansion. Other aspects of land use planning may also be relevant to contaminated land, such as the Integrated Coastal Zone Management and agri-environment programmes identified in the 6th Environment Action Programme.
- **The European Community Biodiversity strategy:** This strategy and recently adopted Action Plans [20], in particular the Action Plan for the Conservation of Natural Resources recognises the quality of the soil environment as an important factor in biodiversity
- **Pollution prevention controls:** Controls on the prevention of environmental emissions to soil and the requirements for restoration of contamination (such as the Integrated Pollution Prevention and Control Directive [21]) and controls on management of waste (such as the Waste Framework Directive [22] and the Landfill Directive [23]) can interact both technically and administratively with the implementation of solutions to contaminated land problems.
- **Environmental Liability:** The EC Draft Directive on prevention and restoration of significant environmental damage (environmental liability) [24] proposes the introduction of a strict liability regime for listed activities which may give rise to

certain categories of environmental damage. The categories of damage include serious harm to human health as a result of land[10] contamination. The Draft Directive also proposes fault-based liability for any other activities which cause damage that affects the favourable conservation status of biodiversity. The regime will therefore be relevant to dealing with contaminated land in the future.

- **Integrated assessment of impacts on human health**: The 6th Environment Action Programme [16] identified the environment and health as a priority issue requiring the adoption of a more holistic and comprehensive approach. The proposed approach includes an assessment of the routes – including air, water, soil and food - by which contaminants reach the human body and the identification of the most effective course of action needed to minimise exposure levels.

These topics need informed assessments of the relevance and impact of contaminated land to address the common and overlapping issues in an effective way. In turn, policies and practices to deal with contaminated land need to link to the emerging approaches for dealing with wider themes.

1.1.5 The need for new solutions

The focus on developing integrated and sustainable approaches has resulted in a shift in attention from the assessment of problems to the formulation of solutions that will meet both the present and future needs of society.

The need to focus on solutions applies just as much to contaminated land. However, this is taking place against a backdrop of limited information about the full extent and significance of contaminated land, of changing attitudes and systems, and of concerns that decisions taken now should fit within a vision of a sustainable future. Current approaches focus on better-informed and sustainable solutions, which will manage the contamination effectively and restore the social, environmental and economic value of the land.

1.2 References

[1] CONSOIL 2000: *Proceedings of the Seventh International FZK/TNO Conference on Contaminated Soil*. 18-22 September 2000, Leipzig, Germany, Thomas Telford Publishing, ISBN 0727729543

[2] NATO / CCMS Pilotstudies: *http://www.nato.int/ccms*

[3] IHPA – The International HCH & Pesticides Association: *http://hjem.get2net.dk/HCH-Pesticides/*

[4] IAEA – International Atomic Energy Agency: *http://www.iaea.or.at/*

[10] defined as soil and subsoil

[5] ISWA – International Solid Waste Association: http://www.iswa.org/

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[10] NATO/CCMS Pilotstudy on Evaluation of Demonstrated and Emerging Remedial Action Technologies for the Treatment of Contaminated Land and Ground Water (Phase III): http://www.nato.int/ccms/ and http://www.clu-in.org/

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[20] European Commission (1998): *The European Biodiversity Strategy*. COM (98)42.

[21] Council Directive 96/61/EC of 24 September 1996 concerning *integrated pollution prevention and control*, Official Journal L 257, 10/10/1996.

[22] Council Directive 75/442/EEC of 15 July 1975 on *waste*. Official Journal L 194, 25/07/1975

[23] Council Directive 1999/31/EC of 26 April 1999 on *the landfill of waste*. Official Journal L 182, 16/07/1999

[24] EC Draft Directive on *prevention and restoration of significant environmental damage (White Paper on Environmental Liability).* Issued by DG Environment on 30/07/2001

CHAPTER 2 THE CONCEPT OF RISK BASED LAND MANAGEMENT

“The policy of being too cautious is the greatest risk of all"

Jawaharlal Nehru

Chapter 1 of this report described the context for solutions to the problems of contaminated land. This includes a number of factors, ranging from the nature of the problem to the inter-relationship with other environmental issues at a European level. Because of these factors, perhaps in particular because of the underlying scientific and technical challenges, decisions about risk assessment and sustainable solutions for contaminated land problems can be complex. As a result, the legacy contamination often remains as a negative environmental and economic impact on land and water resources.

CLARINET considers that an intellectual framework for management of contaminated land would assist in structuring this decision-making process to achieve sustainable solutions. The concept of *Risk Based Land Management (RBLM)* aims to fulfil this role. It focuses on legacy contamination and allows for regional and site-specific solutions in policy and other decision-making across Europe.

2.1 Key issues

Risk Based Land Management 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 (*figure 2.1)*:

fitness for use

protection of the environment

long-term care

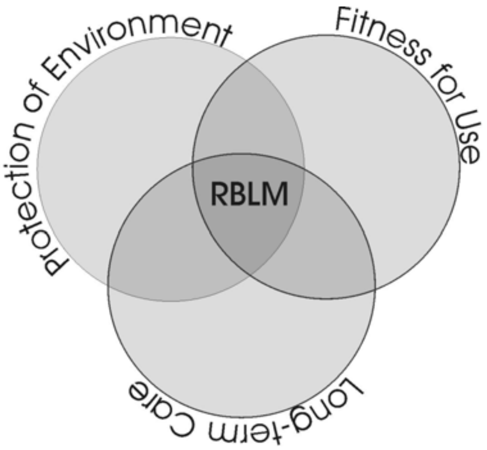

Figure 2.1: The main components of RBLM

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 *(figure 2.2).*

Figure 2.2: The architecture of RBLM

This Chapter discusses the RBLM concept further and the way it can be applied to achieve this balance.

2.2 The term "Risk Based Land Management"

The term Risk Based Land Management appears similar to other expressions used in the context of soil contamination, for example *Risk Based Site Management*. However, for CLARINET's purposes the intention is to have a broader meaning. RBLM considers the issues from a larger scale perspective, and covers the full range of contaminated land problems for which regulators and decision makers are responsible. The constituent terms of the concept are carefully chosen, and are used as follows:

Risk describes the combination of the probability and the effects of contamination, for example adverse environmental effects on human health, on ecosystems, or on water resources. If an adverse effect has occurred, the consequences are often described as *damage*[11]**.** Poor soil and water quality may in turn lead to adverse social and economic effects.

Land represents a geographical area. For example, it could be a single site, or it could be a region such as municipality or larger area. It also includes the soil, surface water and groundwater beneath the surface of the land, adding a third dimension to the traditional spatial planning interpretation of land.

Management is a set of activities involving decisions about assessment, remediation, land-use restrictions, monitoring, spatial planning, *aftercare* and other issues. In the context of risk management, it is a much broader activity than 'choosing a remediation technique'. It includes all the aspects of developing and implementing a sustainable approach. The scope of this management may also be wider than the contaminated land issue. Other environmental impacts and stressors may need to be dealt with at the same time. There are also different types of "manager" of land - for example, the owner or user of an industrial site or a municipal authority.

Risk Based Land Management in the CLARINET sense is therefore a general strategy with three components, and not a practical implementation of existing protocols such as the RBCA (1995) or CONCAWE (1997) system, which apply to individual sites.

2.3 The aim

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:

[11] Adverse environmental effects are generally considered as the result of a process where some potential hazard (a toxic substance or other agent) affects a target to be protected (people, animals and plants, ecosystem processes, water resources or buildings). For this process to operate there must be a connection (*a pathway*) between the potential hazard (*the source*) and target for protection (*the receptor*).

- **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.

2.4 The components of RBLM

2.4.1 Fitness for use

This 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.

2.4.2 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[12]. 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*[13] and the *preventive principle*[14] 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[15].

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[12] 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)

[13] **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)

[14] **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)

[15] see Chapter 4 "Brownfields – wider issues relevant to contaminated land"

2.4.3 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.

2.5 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 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 below based on the underlying three components of risk based land management: *fitness for use*, *protection of the environment* and *long term care*.

2.5.1 Risk reduction

The initiation of decisions relating to risk reduction comes from the results of *risk assessment*, which in turn can inform the choice and objectives for solutions. However, the final choice about risk reduction needs to consider the key decisions within RBLM:

- Time frame; and
- Choice of solution.

These are discussed in more detail below.

Time frame

One key question in relation to the timeframe is determining when to intervene to control or reduce risk. This requires prioritisation and risk assessment procedures based on an assessment of the fitness for use of the land and of the need for protection of the environment. Many Member States and industries have already developed or are in the process of developing this type of approach in their decision-making frameworks for contaminated land[16].

The CARACAS project[17] considered a number of aspects of risk assessment relevant to determining when action is necessary and to priority setting in relation to human health and environmental risk. Clearly, in terms of total resource use, it is equally

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[16] FERGUSON (1999)

[17] CARACAS – Concerted Action on Risk Assessment for Contaminated Sites in Europe: *http://www.caracas.at*

important to decide when it is safe to postpone action on sites to avoid unnecessary expenditure.

However, the need to conserve or enhance a resource – for example soil or water - may also set the timeframe for action. Action may be justified sooner rather than later because the long-term care requirements are too great a burden. There are other *drivers* for action, for example the need to reuse the land or to increase the value of a property portfolio.

The urgency of a site remediation is therefore a function of one or more of these environmental, economic and social factors, and for most large projects a function of a combination of all of them.

Choice of solution

The factors that affect the urgency or priorities for action also determine a key interface between timeframe and choice of solution, which is when the solution needs to become effective and for how long. This is discussed further in Chapter 6.

Another factor in the choice of solution is the way in which the solution relates to the underlying risk. The process underlying the mechanism of environmental risk is often described in terms of a *source-pathway-receptor* analysis (*figure 2.3).* This is one of the fundamental approaches to assessment of contaminated land and development of solutions. In this context, the *source* is the contamination in the soil or water[18]; and the *pathway* is the linking of the contamination and the effects at the receptors of concern.

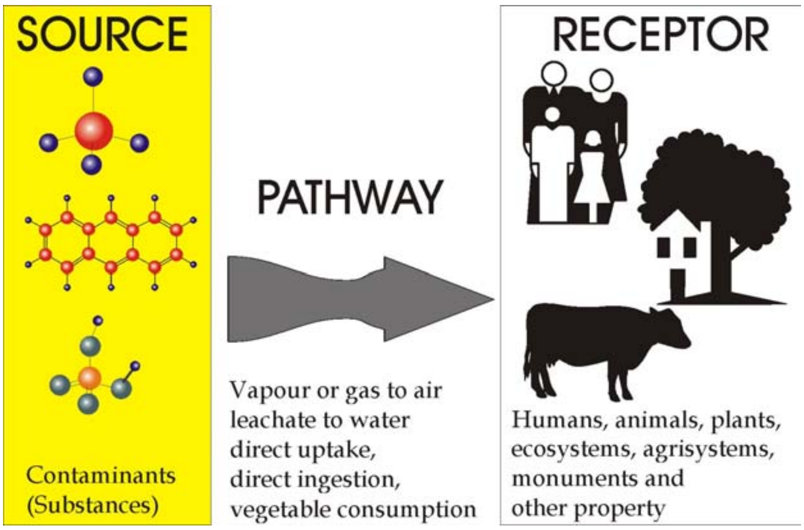

Figure 2.3: The source-pathway-receptor paradigm

In principle, risk reduction may be achieved by removing the *source*, by controlling or eliminating the *pathway*, or by removing the *receptors*. Each of these different

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[18] In other contexts, the term source can mean the origin of the contamination, for example the industrial process.

approaches has a different interface with the three components of RBLM. For example, at the simplest level of analysis, removing the source may use other resources and have an overall negative impact on the environment. Controls on pathways may have a lower initial resource use but have long term care implications. Removing receptors may be costly or socially problematic. This analysis is also explored further in Chapter 6.

2.5.2 Land use related requirements

Practical needs

Different land uses have different needs in terms of the condition of the land. For example, some land uses require direct access to the soil, preventing the use of surface containment measures like capping with concrete or asphalt. Others may require the preparation of the site for geotechnical purposes, for example to support foundations. This type of consideration can be included in alongside the assessment of "*fitness for use*", resulting in an assessment of **"***fitness for purpose***".**

In some cases, the polluted layers in a site may contain rubble, rubbish and coarse waste materials requiring excavation for other reasons, such as construction work. This could make excavation and removal an efficient solution to risk reduction. Often in these cases, on-site recycling and re-use of debris is possible and can reduce demand on primary aggregate resources.

Spatial planning requirements

Spatial planning decisions involving contaminated land cannot be made effectively without considering the quality of the land and the nature of any land management solutions used to deal with contaminated land.

At a site-specific level, the most important decision is usually the quality of land for a particular use, whether this is for the known or current use, or in relation to potential future uses.

Even where there is a known use, some of the particular details of use may not be realised at the time of treatment of the land. They may include unmonitored changes, where, for example, an owner carries out activities allowed as part of his normal use of the land[19]. Where there is a known use, the assessment of fitness for use should consider all possible additional activities on the land allowed within the use classification.

It is also essential to consider the effect of the use of the land, or a change of use of the land, on the characteristics of the land – including the hydrogeological characteristics - and the behaviour of contaminants. This may not only affect the fitness of the land for use but also cause the contamination to have an unacceptable

[19] A typical example is where the permission to build housing also allows later additional work by the house occupier, for example to build himself some small extra space, which may involve soil excavation.

impact on the environment. This may make the particular use of the land an impractical proposition.

There may be a very different use in the future if the pattern of land uses changes[20]. Long-term management of information is essential to retain knowledge about what has been done and what future implications there might be for land use. This may include record keeping such as land "log-books" or registers including information on land condition.

A land use change in the future requires a detailed consideration in relation to the components of RBLM. The standard of remediation that leaves the site fit for one use would need reassessment for a new use. If treatment of the contamination has relied on controls on pathways (or on other ways in which the receptor has access to the contamination), or if the source reduction has been to a limited overall standard, then the land resource may not be as flexible. For the future, at a strategic level, this may not be adequate in conserving land as a resource.

Incorporating RBLM into spatial planning policies and systems is one way of managing contaminated land effectively. Strategic policies can consider the overall interaction of development with land quality to achieve optimum use of land. This includes considering the wider issues of environmental protection and resource conservation[21]. On a site-specific basis, spatial planning controls can manage the continuing implications of long-term care requirements linked to particular solutions.

2.5.3 Using natural capacities in the soil and water environment

Interestingly, until comparatively recently the role of the various properties of soil in risk management have been either largely ignored or given little strategic thought in terms of using these for the benefit of both man and the environment. A similar argument applies to groundwater, although there is a longer history of using the natural characteristics of the underground matrix of soil and groundwater layers to attenuate pollution.

The soil environment has some interesting characteristics, which may help in risk reduction. Soil is a stable and spatially structured living environment. Its natural capacity to act as a barrier can be used in containment techniques, especially as it has a natural capacity to biodegrade or otherwise change the characteristics of substances. If these natural capacities are available, the costs of remediation solutions could decrease.

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[20] For example in brownfield redevelopment where commercial or even industrial areas are being converted to more sensitive uses such as housing or leisure activities.

[21] For example it may not be appropriate to allow certain types of development if they will cause an unacceptable environmental impact, eg by mobilising contaminants, or restrict or interfere with other environmental improvements, eg groundwater clean up.

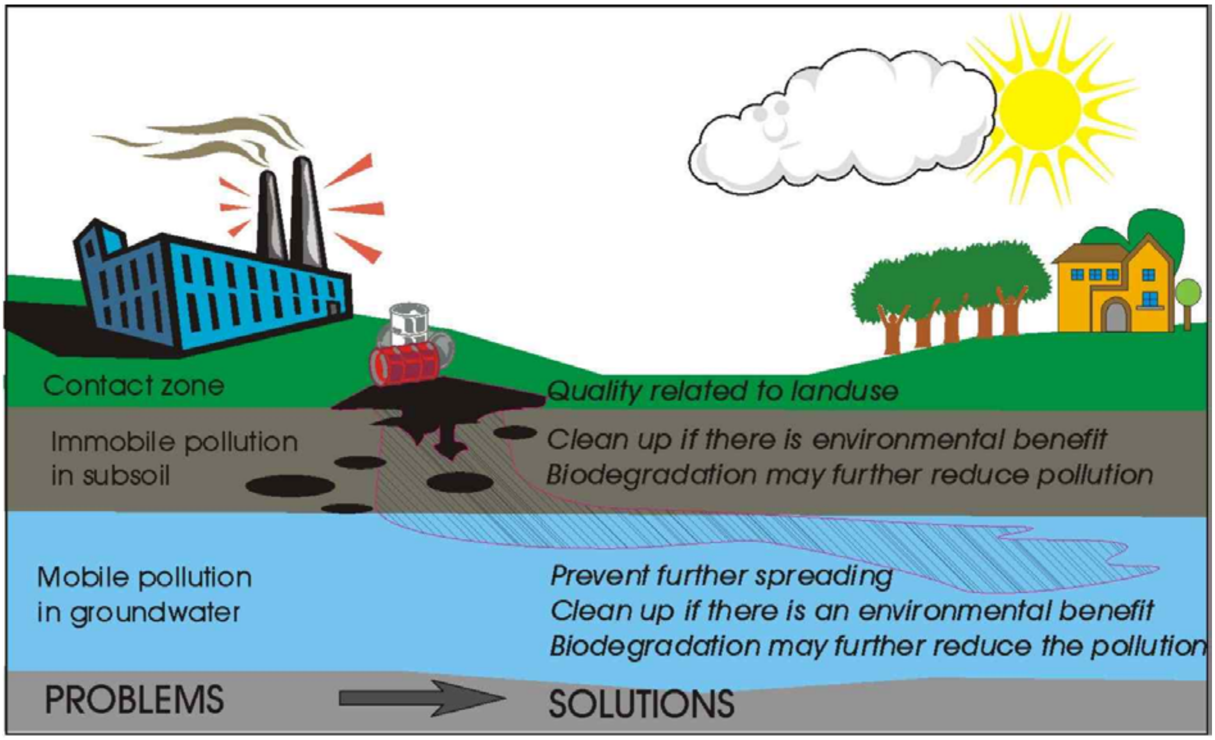

Figure 2.4: Conceptual model for the design of a risk based cleanup solution that makes use of natural soil capacities

Exploiting the natural capacities of soils or groundwater in remediation or contaminated land management solutions will have to meet general requirements for sustainability, and can be considered within the RBLM framework (*figure 2.4.*). For example, the use of the soil for containment will have to meet the same requirements as other containment techniques, such as waste disposal sites. These requirements will relate to the need for the land to be fit for use, for sufficient protection of the environment (including resource use) and for long term care.

One relevant issue is the extent to which the resource of soil or of groundwater is considered as a resource to be protected from any change. At present, for example, the EU Groundwater Directive (80/68/EEC) prohibits any discharges of hazardous substances into groundwater. This may restrict the use of substances that enhance biodegradation.

However, if the application of certain substances in groundwater to stimulate natural attenuation is temporary, of short persistence and has negligible long-term effects on the quality of the groundwater, it could be assessed as acceptable scientifically - even from a long-term point of view - for soil and groundwater protection. The same may hold for small-scale dilution and dispersion of the polluting substance during its degradation.

CLARINET takes the view that it is vital that soil and water resources are valued and protected properly. There are two equally important dimensions in achieving integration of resource protection with contaminated land management. One is to prepare an optimal plan combining use of the resource with its protection and restoration. The other is to consider all the components of RBLM for each site to ensure the full assessment of implications for natural resource protection, conservation and enhancement. Considering natural processes allows for a wider range of potentially sustainable solutions for both dimensions.

2.5.4 Costs

Types of cost

The cost of remediation work is often an overriding factor in decisions. It is all too easy to take a narrow view of costs, based only on obvious direct costs of remediation, and ignore wider types of costs, some of which are related to the components of the RBLM analysis, such as:

- Indirect or "opportunity costs", for example where the land is not **fit for use**
  - because remediation has not taken place; or
  - where there is a loss of income caused by delay in being able to use the land because the remediation process is slow;
  - where a particular land use is not possible if limited standards have been applied.
- Components related to protection of the environment,
  - for example to prevent environmental damage; or
  - burdens falling on different sectors or "third parties", for example a remediation process which uses a large quantity of off-site material may in effect place the burden of renewing that resource onto someone else, or a negative impact on an ecosystem may not be noticed for many years.
- Long term components, particularly where there is a requirement for **long term care**, or where a resource may need to be restored in the longer term.
- Costs relating to different financial mechanisms for providing the funding (such as those which use income and those which require transfer of capital or exchange with other assets).

The comparison can be made more complicated by financial accounting conventions and by the desire to avoid financial costs today, when they can be postponed to the future.

Balancing costs and benefits

Costs and benefits can be considered within RBLM as part of integrated decisions considering fitness for use, protection of the environment and long term care. In particular, RBLM offers a structured way of identifying the benefits and disbenefits of different options. These can then be balanced against the costs to produce a sustainable solution.

Decision support systems can help to structure the overall analysis and to balance the different costs and benefits/disbenefits. They also make cost comparisons more transparent. Identifying costs and evaluating cost effectiveness is discussed further in Chapter 6.

2.5.5 Involving stakeholders

Contaminated land is the same as any other environmental issue in terms of the range of "***stakeholders***" - those who have a direct or indirect interest in the outcome of decisions. For some aspects it is more complicated, since it often touches at the heart of a society or individuals in that it affects not only their own immediate environment, but also the value of something precious to them - their land.

Dialogue with stakeholders may affect the choice of certain solutions over others. It will have to deal with "values" which are difficult to express in terms of risk or utilitarian concepts like land use or soil function. The conservation of a pristine underground environment and the conservation of geologically or archaeologically important sites are examples of this.

2.5.6 Managing uncertainties

Uncertainties are perhaps the most misunderstood concept in the field of risk analysis even though the uncertainty analysis is an important component. It can indicate technical errors (standard deviation, variability, or random error), lack of knowledge or data / information, or even more subjective aspects (as expert judgement, quality of the problem formulation).

There are many scientific and technical uncertainties in contaminated land decision-making. The final report of the CARACAS project discussed a number of the uncertainties in risk assessment[22]. Uncertainties will always be there. RBLM provides a way to deal with them in a systematic and explicit way. This is important, because in risk management, some approaches lead to more certainty than others.

For instance, treatment to reduce contaminant availability is more likely to have scientific uncertainties than excavation of polluted soil. If the remediation aims to reduce a particular degree of risk, there will be uncertainties in the scientific calculations of the clean-up goal. Knowledge about the toxicity of contaminants may change in future, leading to either more or less strict remediation targets. In addition there may be contaminants present in the environment which have not yet been identified as toxic.

Scientists may discover much more in future about the way in which natural resources respond to pressures such as contamination, which could lead to a greater or lesser need to protect them, or a need to manage the remediation of contamination in a different way to work with these responses. Inevitably, there will be aspects not yet realised that have implications for long-term care, for example the effect of

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[22] FERGUSON *et al* (1998)

climate change on other soil and groundwater behaviour that in turn affects contamination.

Apart from the scientific uncertainties, there may be uncertainties in the needs of society, particularly in the future. This is not just a question of knowing whether the land-use may change or not. The way land is used in the future may be very different from the forms of land use known today. For instance, it may be necessary to consider whether land use related remediation, particularly where this is by controls on the pathway or receptor, may prevent future use of land for underground building and infrastructure.

These uncertainties translate into land management problems, both in regard to environment and to spatial planning. However, managing scientific uncertainty is not a new concept. Two extreme positions are:

- to set very stringent and highly precautionary requirements (building in very conservative factors of safety to allow for unknown science); or
- to take a *laissez faire* attitude to assessing the risk (assuming that problems caused by lack of action today will be dealt with by the society of tomorrow society, as today's society has to deal with yesterday's legacy).

On another axis, the choices are between choosing remediation targets or approaches on an arbitrary basis, and introducing time-consuming and complex systems that do not easily allow decisions when factors are unknown.

RBLM aims for a sensible approach that formally considers long-term or wider issues and uses risk assessment to make the uncertainty explicit. This ensures that the result is precautionary and structured, but not excessive in terms of cost or rigidity. RBLM also always falls on the side of the precaution. As knowledge increases, the uncertainty will become less, and the solution will tend towards the perfect balance (*figure 2.5).*

Managing the unknown potential needs of society is more difficult, and to a large extent will always be a political choice, based on priorities for the current generation as much as for the future. It has to be based on the general principles of sustainable development. What RBLM can offer is a means of identifying and evaluating the potential benefits of a range of options.

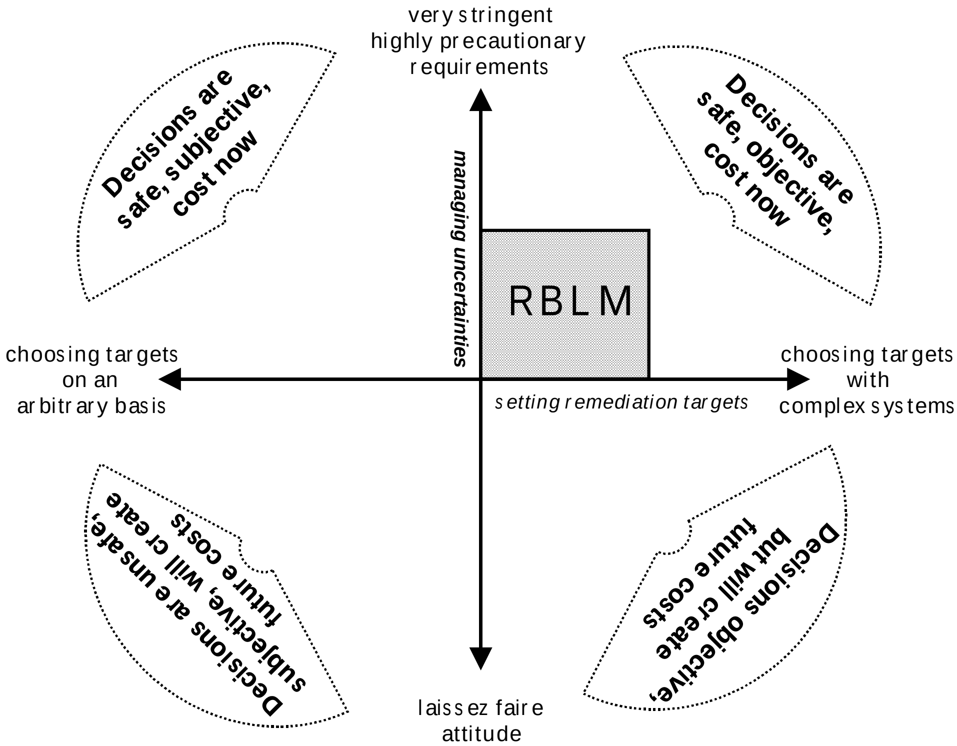

Figure 2.5: Managing uncertainties in decision making

2.5.7 Wider management constraints and influences

Who decides?

Whatever the outcome of the theoretical analysis of the components of RBLM, there are other external factors influencing its application in practice. One set of factors relates to the decision making process. Who decides and how do they decide? Will it be a dynamic and open decision making process, involving all interest groups, or can a single decision-maker apply a protocol or mandatory decision support system?

The conceptual idea of a "manager" in the RBLM approach does not automatically imply that there is a single decision-maker, although it may be an individual. The manager may be the competent national, regional or municipal authority. These authorities will have to act within their mandate to represent public interest. For industrial sites, the manager may be the owner, who can make decisions within certain limits imposed by the authorities. Individual site managers may have other boundaries set by corporate policies.

Clearly, whoever the decision maker is, good decisions are based on good information, on understanding of both the short and long term consequences and on a systematic approach. Transparency and recording of assumptions and uncertainties is also essential to promote confidence and manage the solution in the long term.

Other management constraints and influences

Another set of factors influencing application in practice relate to external constraints on the process. There may be requirements set by those providing the funding, whether this is direct (for example from public authorities or from investment by others) or whether it is indirect (for example from the citizen in the form of taxation). Legal constraints may prohibit some treatment and risk management solutions.

Some of these constraints may be essential interfaces with other aspects of protection of society and the environment, others may require careful application and review if they endanger a fully sustainable future.

2.6 The future

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 type of treatment 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.

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. The process of applying RBLM includes balancing the three components of fitness for use, protection of the environment and long term care and considering these in the practical context of decision making (*figure 2.6).*

Further chapters in this report discuss particular aspects of the CLARINET work in relation to the RBLM concept.

Figure 2.6: The RBLM process

2.7 General background references

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CHAPTER 3 RBLM AND THE PROTECTION OF WATER RESOURCES

"Water takes on the character of the rocks through which it flows".

Plinius

CLARINET considered two particular cross cutting policy themes during the project:

- protection of water resources; and
- redevelopment of brownfield sites.

This chapter discusses the issues relevant to the concept of Risk Based Land Management (RBLM) in relation to the protection of water resources. It focuses in particular on the most affected and vulnerable part of water resources, **groundwater.** Chapter 4 discusses brownfields.

3.1 The problem

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, - it is out of sight and mostly out of mind. 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[23] (*figure 3.1).*

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 widespread pollution by nitrates, which is now specially addressed in the EU nitrate directive[24], may serve as an example.

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[23] Environment Agency for England and Wales (2001)

[24] EC Nitrate Directive (91/676/EEC)

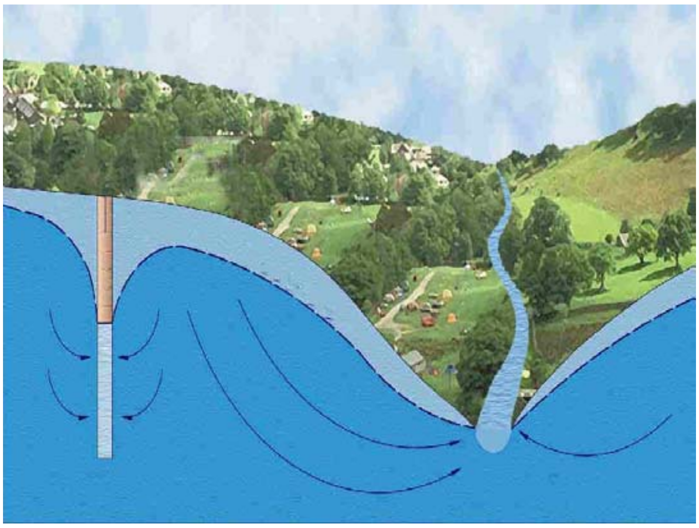

Figure 3.1: A river is an outcrop of groundwater[25]

3.2 Issues at the European level[26]

Under the European Groundwater Directive[27], there is 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.

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[25] from UK Groundwater Forum "*Groundwater: Our hidden asset*", published by the British Geological Survey

[26] CLARINET carried out a survey of all participants, representing most of the European Union Member States and EFTA countries like Norway and Switzerland, 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. Conclusions have been summarised with the CLARINET Working Group Report (2002) *Contaminated Land and its Impact on Water Resources – Analysis of Questionnaires*; available on http://www.clarinet.at

[27] EC Groundwater Directive (80/68/EEC)

[28] EC Water Framework Directive (2000/60/EEC)

This Directive may provide an additional legislative driver for the remediation of contaminated land[29]. 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.

The Water Framework Directive requires an understanding of the pressures on water resources. To aid this further, characterisation of river basins and their associated water bodies (groundwater) has to be carried out. These should review the impact of human activities on groundwater, of changes in groundwater levels and on groundwater and surface water quality. Inventories of a number of activities and sources, such as abstractions (potential receptors), discharges to water, large industrial sites, and contaminated land will be required. Just for these aspects of the requirements of the Directive, the timetable for carrying out the analysis of significant pressures will be very challenging.

The Directive is set to stimulate more integrated thinking about land in a three dimensional way and the soil-groundwater-surface water interactions, in terms of contamination giving rise to polluted infiltration and run-off. From a technical viewpoint 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.

A Daughter Directive on groundwater quality and related standards is being drafted in 2002. Prevention and limitation of inputs of pollutants is the starting point for groundwater protection and specifically for point pollution. Specific measures and criteria for this obligation should be set out in the future Groundwater Directive. This will indirectly influence the setting of site-specific remediation targets for clean up related to the use of the groundwater bodies and/or the ecosystems they influence.

3.3 The relationship to RBLM

Current water protection policies have already moved from merely control of discharges into surface waters towards system orientated management approaches. Risk based land management offers a logical next step in the integration of soil and water management.

The extent of the problem of water resources pollution, the legislative drivers and the key issues relating to the protection of water resources versus contaminated land management impact directly on the two key decisions relating to the remediation of contaminated land: the **timing** and the **design of the solution**.

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[29] HARRIS (2001)

For the timing aspects, two opposite situations can be seen. Priorities for actions can be based on

- **'soil' clean-up criteria** (when risk to human health or the terrestrial environment have to be reduced or an economic reuse of the soil is planned); or on
- **'water' clean-up criteria** if the main receptor is surface water or groundwater.

The key issues identified at European level will also influence the choice of solution. The best strategy to meet all requirements (i.e. risk reduction, land use, management) includes consideration of environmental side effects, available space and facilities, local perceptions, and other issues. For the remediation of groundwater resources, particularly in urban areas or with large-scale pollution, the best risk management strategy is usually source removal followed by breaking the pathway. This can also include taking natural attenuation into account (however this requires a more substantial time period and long term monitoring), monitoring of existing processes and / or restriction of use of the water (i.e. management of the receptor).

In the cases where monitored natural attenuation is the only viable option, it is essential to recognise the long time period in which the groundwater (and associated surface waters) may be affected. This requires incorporating a realistic, practical timeframe, which potentially conflicts with the time constraints for achieving "Good Status", imposed within the Water Framework Directive. Exemptions will be needed based on the RBLM approach.

Within the Water Framework Directive, Member States may aim to achieve less stringent environmental objectives than those required when both the following conditions are met[30]:

(a) "Member States determine that the body of water is so affected by human activity or its natural condition is such that improvements in status would be infeasible or unreasonably expensive"; and

(b) "The establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the River Basin Management Plan and those objectives are reviewed every 6 years."

There is a need to integrate the approaches for management of contaminated land with those relating to the Water Framework Directive. RBLM can help to find that integrated approach, first by using the components to identify common issues, and then by examining the aspects of RBLM in practice in relation to this particular issue.

3.3.1 Fitness for use

At first sight, there is a limited overlap between the need for land to meet "fit for current use" criteria and the need to ensure that contamination beneath the ground is not causing a problem in relation to the environment (see next heading), for instance

[30] EC Water Framework Directive (2000/60/EEC)

to the water catchment. However when it is realised that fitness for use of groundwater should relate to all "users" of groundwater, including the surface water ecosystems that the groundwater supports, fitness for use and environmental protection do show a large overlap.

In applying the RBLM approach to groundwater, setting remediation targets for groundwater should at least relate to "fitness for current use". Thus if the groundwater is being used (or can be potentially used) for drinking water then the remediation targets will be more related to drinking water standards than if the groundwater was simply discharging into surface water. In the latter case the remediation targets for current use would relate to the ecological status objective for the river. This will usually be less stringent than for drinking water, although it could be more stringent for aquatic ecosystems that are more sensitive to water chemistry (both natural and polluted) than humans. Drinking water standards only relate to people and should not be used as surrogate values for aquatic ecosystems.

The key challenge in "fitness for use" assessment is to understand the source-pathway-receptor linkage thoroughly, through the development of a conceptual model, and derive the use-related associated remediation targets from the short term and longer-term risks involved from all sources. In some cases the use of the water resources will change. For instance, a new drinking water supply catchment may be created at the boundary of the site. It is therefore necessary to anticipate future uses.

There will be other challenges in balancing the respective approaches needed for soil and water. If the results of the monitoring of the quality of the groundwater resources show degradation, will it be possible to implement the necessary measures in order to reclaim the aquifer once a site has already been remediated to be fit for use? Who will be responsible for this? These questions are especially important since in many countries there are different regulatory bodies or jurisdictions dealing with land and water.

3.3.2 Protection of the environment

Groundwater, surface waters and their associated aquatic ecosystems are integral components of the environment. Society as a whole needs to have a better understanding of the influence of the land use and the flux of contaminants from soils through groundwater to surface water. Clearly any action to remediate contaminated land needs to consider both how to reduce and prevent harm or pollution to water resources and how to safeguard them. This is already a common feature of policies, legislation and practice at European and national level.

Groundwater resources must be seen as an accumulating medium for pollution. They can be

- a **receptor** (especially if used for drinking water but also from the perspective of the EU Groundwater Directive[31]);
- a **pathway** (when flowing into rivers); and
- a **sink** (when groundwater movement is very slow such as in deep sedimentary basins).

A site-by-site approach, as usually applied within the traditional contaminated site management framework, can be a restrictive approach. Certain situations are better dealt with by a broader geographical approach, taking into account the impacts of several sites on the same resource. This applies for example where cumulative risks come from the degradation (cumulative or progressive) of the quality of the water resource along pathways. In fact, these two different approaches are complementary. An integrated assessment and management of all contaminated sites that may affect a river system (including groundwater), based on a conceptual model of the river basin catchment (considered as the whole receptor; one of the requirements of the Water Framework Directive) should be developed and applied.

Risk-based decision-making

Risk based decision making has already been central in the drafting of the technical annexes of the *European Landfill Directive*[32]. In particular, the criteria for defining waste admission into the different categories of landfills (inert, non-hazardous, and hazardous waste landfills) were defined on the basis of an estimation of the potential impact that these landfills might have on groundwater resources, for a conservative landfill scenario.

Target values for groundwater quality in the vicinity of the landfills were selected based in part on the European Water Directive, and points of compliance were identified at specified distances downgradient from the landfill site. Waste release was adjusted in an iterative fashion, such that the impacts observed in the groundwater at the points of compliance were at all times lower than the water quality objectives. These impacts were evaluated using groundwater flow and transport models.

The main 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);

[31] EC Groundwater Directive (80/68/EEC)

[32] EC Landfill Directive (99/31/EEC)

- remediation of past pollution where this is necessary to protect the aquatic environment, terrestrial ecosystems and water users.

Several key issues should be addressed, which are discussed further below.

Groundwater as a source of drinking water

There are differing perspectives of 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.

Point of compliance

The points of compliance 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 (*figure 3.2).*[33] The Groundwater Directive (and the Water Framework Directive) is 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).

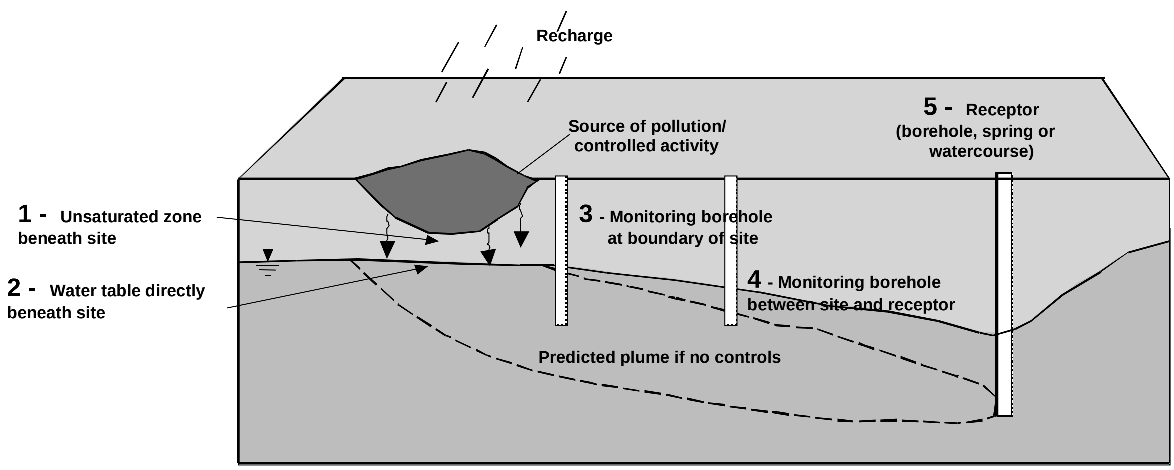

Figure 3.2: Points of compliance in different countries[34]

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[33] DARMENDRAIL *et al* (2001)

[34] DARMENDRAIL & HARRIS (2001)

Enhanced understanding

Many areas of science are still being explored to develop better solutions – in particular knowledge about natural processes, interactions between contamination and the effect of hydrogeological and biogeochemical factors.

Definition of acceptable levels

Acceptable levels need to be set for water quality for residual pollution for environmental protection. This also feeds into the requirements to set standards for 'fitness for use' where the use of the site would not be feasible if contamination was still having an unacceptable effect on water resources.

Time scale

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[35].

Geographical scale of the area of consideration

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.

3.3.3 Long-term care

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.

3.3.4 RBLM in practice

Other aspects, which emerge on the interface between contaminated land management and water resources protection relate to:

Risk reduction

The aim in a preventive policy is to remove or control all sources of contamination that could affect groundwater. This can be an impossibly expensive and unfeasible undertaken in certain cases. Some European countries have therefore developed different approaches for "new" and "old" pollution (prevent "new" pollution, remediate "old" pollution).

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[35] MÜLLER (2001)

Various methods for groundwater cleanup are well documented now[36]. In recent time, the discussion has increasingly focussed on extensive biological methods and Monitored Natural Attenuation (MNA).

The use of MNA encourages a better understanding of processes, and can be a reasonable strategy for some of the problems. It forces better site characterisation and therefore better understanding of the issues in order to define acceptable levels of residual pollution and hence remediation objectives. A good conceptual model of the site and the pollutant fluxes is a vital precursor to deciding on a remediation option. By controlling the hydrogeological and the biogeochemical conditions, it can also in effect modify the contamination source and reduce the risk.

However, at present, it can be difficult to compare the advantages and disadvantages of MNA over other options in relation to all the components of RBLM. It is also not an option under all conditions, and better information to determine operating windows or development of combinations of MNA with other technologies may improve its applicability.[37]

MNA as a single option for the remediation of groundwater and soil may not suit for many reasons such as:

- the immediate risks from the impact on the receptor;
- additional risks from persistent or unknown pollutants;
- the long timescale, in particular for land use requirements (see below);
- public acceptability.

Land use requirements

Some specific issues should be considered in relation to the interaction between land use and remediation of water resources or their protection from the impacts of contaminated land:

- Possible need for space, sometimes outside the polluted site, in particular when downstream groundwater is contaminated, for monitoring or the location of the remediation plant;
- Setting and delivering remediation objectives at a regional scale, in particular in urban areas where several sites are impacting the same resources.

Using natural resources

Some of the risk management options do not consider exploitation (consumption) of natural resources, in particular water resources, as an important criterion to be taken into consideration. The development of an integrated contaminated sites

[36] NATO/CCMS Pilotstudy on Evaluation of Demonstrated and Emerging Technologies for the Treatment and Cleanup of Contaminated Land and Groundwater (Phase I till III); available on http://www.nato.int/ccms/pilot-studies/pilot007/welcome.html or http://clu-in.org

[37] LAMBSON (2001)

management assessment including groundwater protection in its widest sense should be a solution to this situation.

The attributes of aquifers will be increasingly important in the future. Some are currently considered as strategic or irreplaceable; others are not but could become so in the future. This will need to be taken into account more precisely. The implementation of the Water Framework Directive will provide a legislative driver that will encourage authorities and site owners to focus on this issue.

Costs

Costs are high both for the remediation of groundwater and for the remediation of contaminated soil which would prevent ongoing pollution of groundwater. The risk based land management concept, which allows the choice for fitness for use approaches, particularly for highly and/or widely polluted groundwater, should therefore be embraced in water management as it has been in land/soil management.

Groundwater cleanup can take a long time, and may have consequences for surrounding land uses. These aspects should be taken into account in cost-benefit discussions and the choice of cleanup solutions[38].

It will always be better to pay for preventive measures since in the vast majority of cases the costs of cleanup are very expensive. As already stated, in many cases they are very difficult or even impossible to carry out at all. The costs to society by moving to other catchment areas and the consumption of new natural resources must not be forgotten as important motives for investment in groundwater resource protection.

Involving stakeholders

Involvement of stakeholders is necessary in order to reach a consensus on the protection and remediation objectives.

This is particularly important where ***monitored natural attenuation*** is being adopted as the remediation option, or one option in a group or series of treatment processes. Because of the extensive time scale over which natural attenuation operates (many decades) it is possible that groundwater, which has no immediate use, will remain polluted for a long time. Land use planners must be aware, and records kept identifying the area remaining polluted to ensure that prospective users do not get a false impression of the actual groundwater quality. Land uses that affect the geohydrological balance should be avoided, since they may lead to uncontrolled spreading of polluted water.

Managing uncertainties

For groundwater resources, often considered as a "black box" media, uncertainties can play a major role in both protection and remediation. These require prediction of

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[38] see Chapter 6 "Finding better solutions"

the fate of contaminant species dissolved within a liquid medium (water) being transported through a solid medium (underground and rock matrices) in a very specific environment. There is often little data available, and therefore the prediction is very difficult.

Since there is not yet a full understanding of the science of the sub-surface environment and little data (because it is costly to obtain) from the specific location of concern, decision-making must always be precautionary. Investment in science and/or better site investigation information will usually prove cost-effective in reducing the uncertainty and the degree of precaution taken[39]. However, there is a balance, and that needs to be carefully considered.

Risk managers need to look at the available options to deal with uncertainty by controlling the probability of an adverse effect, the timing and where possible the magnitude. Risk managers have a number of options, ranging from doing nothing (because the risks are under control) to giving strong warnings about the risks to force their consideration. They can also involve all the stakeholders to share information and management responsibilities, take preventive action to reduce the risks, or obtain more information to reduce the uncertainties.

The overall evaluation will consider not only the results of the risk assessment but other elements including economic costs, technical feasibility, social acceptance, regulatory objectives and enforceability. Still, the absence of certainty should not be an obstacle to decision-making; a realistic evaluation of the risk should also evaluate any uncertainties to ensure that a reasonable upper-bound approach has been followed.

Other management constraints and influences

Applying a remediation strategy to a particular site involves a range of activities[40]:

- planning remediation operations;
- site management;
- verification of performance;
- monitoring processes performance and environmental effects;
- public acceptability and neighbourhood relationships;
- strategies for adaptation in response to changed or unexpected circumstances (i.e. flexibility);
- aftercare, including liability issues and cost issues.

For groundwater remediation, additional issues could also become important:

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[39] FERGUSON *et al* (1998)

[40] see Clarinet Report „Review of Decision Support Tools and their use in Europe”

- Management of the surroundings of the site (e.g. through introduction of monitoring wells), particularly in the case of plumes passing through site boundaries;
- Receptor management, in terms of acceptance that new catchment areas and new abstraction wells may be needed, or further refinement of 'protection areas' based on the understanding of pollutant fate and transport over time.

3.4 The future

CLARINET has promoted a better understanding between the participating countries. It has allowed recognition of the differences in approach that are non-technical (i.e. legally driven or culturally different) and those for which a common framework is appropriate. The RBLM concept can equally be applied to land and the associated groundwater and surface water.

It is essential to recognise the substantial obstacles to complete clean-up of **historical pollution** in groundwater, both from a technical and an economic viewpoint. The remediation of **historical** groundwater pollution should be addressed in a similar way to that being accepted throughout Europe for land and soil, i.e. a risk-based approach. RBLM when considered within the Water Framework Directive will help in setting a common framework for European groundwater remediation.

Although in many places contaminants have already been introduced to the underground, the precautionary and preventive principles can still be followed in contaminated soil and water management to prevent further damage and to remedy the problems in an environmentally friendly way. Restoration, together with a progressive reduction of emissions and plumes of mobilised contaminants can lead, over time, to the re-establishment of the good ecological status of aquatic ecosystems or the good chemical status of groundwater bodies.

This has important implications for the practical implementation of the Water Framework Directive:

- The development of strategies to prevent and control pollution of groundwater *(referring to WFD Art. 17)* should stress practical distinctions between 'old' and 'new' contamination. It would also be worth providing a clear picture of how to assess the overall quality of a groundwater body as a resource and how to assess the local impact of a specific activity or point source of pollution on groundwater.
- In order to handle the problem of contaminated land within River Basin Management Plans there will be a demand for new strategies and a methodology for their implementation. The concept of assessing trends at a local scale by determining the behaviour of contaminated groundwater plumes (expanding, stable, shrinking) could serve as a starting point for larger scale point source pollution. Subsequently the principles for monitoring plumes and the procedure for data analyses should be brought together as a coherent instrument.

- Groundwater quality standards are one of the criteria that can be applied to help unify overall regional assessments of groundwater quality. However, in applying this criterion at the local level, the diverse natural conditions throughout Europe have to be taken into account to allow sound decision making. It is therefore important that remediation targets for contaminated land and groundwater, have both to refer to, and be adjusted for, local conditions.
- CLARINET considers that a single set of pan-European restoration targets for groundwater quality is not technically robust and would result in inappropriate standards being set. This is similar to the CLARINET view on soil standards (*see Chapter 5*). A risk-based approach should be adopted that would allow Member States to develop restoration objectives on a site-specific basis. Quality objectives should be developed to protect specific receptors (surface waters, wetlands, humans ingesting water, etc.) in addition to the general objectives of groundwater resource protection, taking into account the local circumstances of each site and water body.
- In practice this means that "new" contamination, which may need to be addressed very quickly, may initially refer to generic values in setting restoration objectives in order to protect groundwater quality. However, it will be necessary to take account of natural background concentrations when **finalising** remedial objectives, particularly if these are above the generic quality standards. "Historical contamination" should be addressed through a risk-based approach, applying best available technology at a reasonable cost (BATNEEC[41]).

3.5 General background references

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[41] *the best available technology not entailing excessive costs*

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CHAPTER 4 BROWNFIELDS – WIDER ISSUES RELEVANT TO CONTAMINATED LAND

"Buy land, they aren't making it any more".

Mark Twain

This Chapter discusses the second of the two cross cutting policy themes considered by CLARINET and relevant to contaminated land: **brownfields**. It develops the work of CLARINET in analysing brownfield policy, programmes and practice across Europe.

Example for a brownfield redevelopment project

4.1.1 Defining brownfield

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 *(box 4.1).*

Box 4.1. CLARINET definition of "brownfield"
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

4.2 A problem or an opportunity?

Previous uses of land, particularly industrial uses, may have resulted in problems of contamination – and the interface with contaminated land problems can be a significant issue in terms of bringing brownfield land back into use. CLARINET therefore identified issues and made recommendations to assist in developing common understanding between those involved in brownfield redevelopment and those developing solutions for contaminated land[42].

The CLARINET report on brownfields identified four main factors for use as a basis for analysis of the information obtained from the different participants and countries in the study:

- Future Use;
- Site preparation;
- Economic viability;
- Legal framework.

These factors have been previously identified as key influences and represented as a tetrahedron model (*figure 4.1*). This model shows that all the factors interrelate with each other, and that problems with any one aspect can affect the overall stability of the brownfield redevelopment process.

[42] CLARINET WORKING GROUP REPORT (2002): *Brownfields and Redevelopment of Urban Areas*

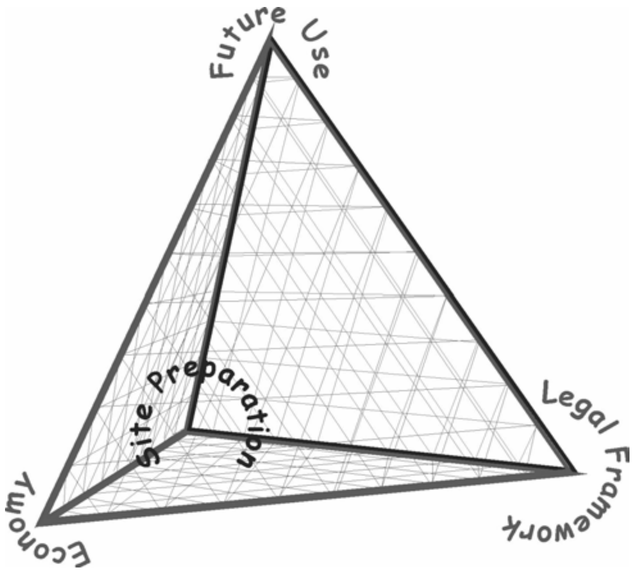

Figure 4.1: The "Tetrahedron Model"[43]

The analysis of information obtained by the CLARINET Working Group identified a number of significant problems relevant to contaminated land management in the context of brownfields redevelopment:

- 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.

Overall, the presence of contamination can be an additional bottleneck in the complex process of redevelopment. Brownfield sites also have other, wider problems, many of which are related to the factors causing the land to become unused, underused or only partially used. These include economic factors resulting in the decline or cessation of the former use of the land, social problems which have resulted from this economic decline and 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 to assist in this. The benefits of this are increasingly recognised. The reuse of brownfields can provide urban, economic and social revitalisation, restore the environment and contribute to the reduction of the consumption of "greenfield" land. The challenge therefore is to develop new ways of overcoming the problems of contaminated land to assist in this process.

[43] GRIMSKI & FERBER (2001)

4.3 European context

4.3.1 Scale

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).

As a result, 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 regional problems, such as those in Lavrion/Attika. New candidate countries for the European Union are equally affected, in some cases at a greater scale.

The creation of brownfields continues. Some newer industries or uses of land, often created on former brownfields, have not been successful, leading to a return of the land to a derelict or underused state.

Another classification of the problem relates to the value of the land. Where brownfield land has a high potential value for reuse, the problem is that the reuse may not deal appropriately with any issues of contamination. Where the land does not have real economic value, the problem is that the land may be abandoned forever. These scenarios are common across Europe.

Example for a brownfield site

4.3.2 Legislation

Many different aspects 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	Spatial planning policies
Contaminated site controls	Urban design requirements
Water legislation	Building codes
Waste legislation	Mining codes
Emissions (or pollution) control	

In different European countries these codes can take different forms, which makes it difficult to analyse what is regulated and how.

4.3.3 Different drivers but common problems

At present, there are differences in overt policies on brownfield reuse in different countries. This partly reflects the differences in extent (or perception) of the problem and the different legal and administrative structures for action. But 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?

4.3.4 What is emerging?

It is clear at a European level that brownfields can have impacts on the local and national economy, on the community and on environmental quality. Indicators are being developed to encourage the reuse of land[44]. Successful redevelopment of brownfield sites is a challenge for both spatial planning and contaminated land specialists.

4.4 The relationship to RBLM

As contaminated land is often one of the obstacles in the regeneration of brownfields, there is a need to integrate the approaches for management of contaminated land with those relating to brownfields. Risk Based Land Management (RBLM) aims to integrate environmental issues with spatial planning issues and can therefore help to find that integrated approach.

This section considers the relationship with RBLM, first by identifying particular issues relevant to the three components of RBLM, and then by examining the aspects of RBLM in practice in relation to brownfields.

4.4.1 Fitness for use

This is the main driver for brownfield redevelopment. The most common trigger for action on a brownfield site is the need to change the use of the site.

The developer will want to know the quality requirements for that "future use". In theory the developer will also have a positive attitude towards ensuring that the quality standards are met, as this will be part of the "package" of selling the site. In practice, the quality requirements will translate to money needed to achieve the necessary standards, and immediately the developer will associate this with an impact on the economic viability of the development.

The investor and the final user of the site will have a different view of the quality standards. They will want to be reassured that the land is fit for use, both now and in the light of potentially changing standards. This confidence in the standards for use requires a very complex mix of science, perception and risk transference.

4.4.2 Protection of the environment

One feature of brownfield redevelopment is that many of the stakeholders see protection of the environment as an obstacle rather than an integral part of the decision making process. Dealing with water pollution is often seen as a significant and unacceptable burden. In extreme cases, the uncontrolled reuse of brownfield sites may achieve economic or social growth, but may transfer the environmental problem elsewhere or may make it worse.

However, the clean up of contaminated land for redevelopment represents a unique opportunity to deal with the wider impacts on the environment. There is therefore a

[44] European Topic Centre on Terrestrial Environment, see *http://terrestrial.eionet.eu.int/*

very real need for the integration of appropriate measures to deal with water pollution and long-term soil health at the same time as the measures to bring the land back into use.

4.4.3 Long-term care

The reuse of land presents an immediate opportunity to revisit the long-term issues. Chapter 2 of this report discusses the need in particular for long-term information and records about the condition of land – redevelopment is one of the best opportunities to make these records.

In brownfield redevelopment many of those involved will have a particular perspective on the long-term issues. Their priority will be to ensure that the change of use of the site is economically viable. In many cases the developer will only be involved during the change of use – he will sell the land very soon afterwards – and will have only a limited interest in the long-term quality of the land. Other incentives and controls are needed to ensure that long-term issues are not ignored.

Developers and others involved in land redevelopment are increasingly aware of – and fear – long term environmental liabilities. This provides an incentive for long-term management of the land, but can also discourage some developers. There is a real need for a balance between ensuring that those who benefit from the land take long-term care, but do not take on a disproportionate burden from the past.

4.4.4 RBLM in practice

Brownfield redevelopment triggers action to deal with contaminated land, and presents an opportunity to balance the three components of RBLM. However, the specific circumstances and the involvement of a wide range of different stakeholders in brownfield development presents a particular challenge for the implementation of RBLM. The general points addressed in Chapter 2 of course apply, and some other specific points are identified below.

Risk reduction

The timescale for clean up is accelerated when land is to be reused. This can achieve clean up on sites which would otherwise have had a lower priority or insufficient resources, but can also restrict the choice of solution. The developer may be tempted by a minimum clean up, or he may not want clean up to take a long time when he needs to finish the development quickly to generate his income.

Science and technology need to respond to this. The developer needs practical information and solutions which he then has the means to implement. These solutions should bridge the gap between the needs of society to protect the environment and reduce the long-term care needed on a site, and the needs of the developer who is providing the impetus for clean up. Chapter 6 discusses some of the issues around finding these solutions.

Land use

In many cases brownfield land provides the link between environmental protection and spatial planning considerations.

At its simplest level the new use of the site will drive the clean up. But at a more strategic level the spatial planning system provides a means to optimise the requirements for clean up, maximise reuse of land and minimise future burdens. It is vital that it does this with regard to all three components of RBLM.

Using natural capacities in the soil and water environment

As discussed earlier in this chapter, one of the main challenges for reuse of the site is to encourage solutions which lead to longer term improvement as well as short term fitness for use and protection of the environment. The timescale for clean up for reuse of land rarely allows for the use of slower natural processes. But some sites may offer an opportunity for both a fast track clean up to achieve the immediate reuse requirements, with an additional, slower, clean up working to provide further longer term improvements. Or longer-term natural processes can be enhanced by a new land use, for example for energy forestry. Choosing solutions is discussed further in Chapter 6.

The type of brownfield land which is less likely to attract new investment and new use can also be managed in a longer-term way using processes which have synergy with the natural environment.

Although not related to natural capacities for clean up, there is a parallel in working in harmony with some of the cultural heritage associated with brownfield sites. Many successful developments on brownfields have linked to the intrinsic nature of the site – and enhanced that for the benefit of the new use. This means that the value of historic buildings and other resources have been both conserved and in some cases enhanced.

Costs

The assessment of costs for brownfield redevelopment is both more and less complex than that for contaminated land alone. There are many other factors to take into account, although often the cost of remediation will be targeted as the reason why a project is unviable. Cost uncertainties affect a wider outcome than simply the completion or otherwise of a project, as the development is linked to a demand for a new use which may be affected if money runs out. It can also be difficult to establish who is really paying for what, and who gets the benefits.

On the positive side a successful brownfield project will attract money and investors both to clean up the land and to create new wealth in the community.

Completed brownfield redevelopment project

Involving stakeholders

This investor and community involvement is a major factor in successful development. Investors will have different agendas and a very different perspective on contamination issues for example to those with an interest in the long term science or technical solutions. Communities may be wary of developers changing their social fabric. They may also be caught between wanting their environment to be improved and fearing what will happen during clean up. Use of the RBLM concept can help to provide a framework for a structured discussion of issues with a range of stakeholders.

Managing uncertainties

Those who will benefit from the project, either financially or because it provides them with somewhere to live and work will want reassurance that the development is safe. Creating confidence in brownfield development is still a challenge, although new solutions such as the provision of insurance cover explicitly covering environmental risk are emerging in most countries.

Scientists and technologists have a major role to play in raising awareness of risk assessment and risk management approaches and in providing a positive contribution to development of understanding of environmental risk.

Constraints and influences on implementation

The "manager" of land for redevelopment is often a very specifically identified person – either a landowner or a developer/contractor working in partnership with a landowner. They will have many other pressures on them, in terms of finance, timeframe and practical issues. All too often contamination is seen as the "deal breaker" – even in cases where the problems it represents can be resolved it simply becomes one issue too many.

However, given the continuous and increasing drive to redevelop brownfields, more and more players are becoming involved in the issue of contaminated land. Their skills can be enhanced and harnessed through training and multi-disciplinary exchange. Expertise in risk based land management should increase as a result.

4.5 The future

This paper has identified a snapshot of issues relevant to brownfield redevelopment from the perspective of CLARINET. There are many other complex aspects which are discussed in the report of CLARINET on brownfields[45] and elsewhere[46].

CLARINET has made a number of specific recommendations for policy, programme and practice in its report on brownfields. These cover:

- Policy and programmes, ranging from the need to prevent the creation of new brownfields to the introduction of strategic land management;
- Land use and planning procedures;
- Site preparation and technical procedures;
- Tools to enhance economic viability;
- Other topics such as conservation of heritage and cultural aspects.

CLARINET has also stimulated the creation of a new network – CABERNET[47] - focussing on brownfield issues in the context of the urban environment. This new group of multi-disciplinary experts, representing a wide range of stakeholders in brownfield regeneration, has been set up under the key action "Cities of Tomorrow" under the EC 5th Framework Programme.

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[45] CLARINET WORKING GROUP REPORT (2002): *Brownfields and Redevelopment of Urban Areas*

[46] Expert Group On The Urban Environment (2000)

[47] CABERNET - Concerted Action on Brownfield and Economic Regeneration NETwork. See www.cabernet.org.uk

Encouraging the reuse of brownfields provides the opportunity to deal with environmental, economic and social issues. Risk based land management fits within this to provide a structured basis for analysis of the essential components of dealing with contaminated land in the context of brownfields.

4.6 General background references

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CHAPTER 5 IMPROVED PROBLEM DEFINITION - DETERMINING THE RISK

"From stethoscope to crystal ball"

This chapter summarises the activities and initiatives of CLARINET to address some of the issues identified by CARACAS[48] and gives some perspectives for future development within the RBLM framework.

5.1 What risk?

The implementation of risk based land management starts with the need for sound approaches on the identification and evaluation of risks from land contamination – **risk assessment**. Contamination can represent a risk to human health, to ecosystems, to ground and surface water quality and to building materials.

As part of its work programme, CLARINET specifically built on the work of the previous Concerted Action, CARACAS[49], to address scientific issues relating to two key aspects of risk assessment - risk to human health and risk to ecosystems.

5.1.1 The approach to risk assessment

Within the context of contaminated land, the assessor should consider risks to human and ecosystem health not only at the contaminated site or area itself, but also in surrounding areas where contamination may be found because of dispersion through groundwater, surface water or air. The risk assessment should result in a clear picture of the risk to the health of human users of the site and surrounding land and the risk to structure and functioning of the ecosystems present on this land.

A proper risk assessment will address uncertainties and quantify them if possible. It will also indicate, through the prioritisation of sources, pathways and receptors, where remediation efforts are likely to be most effective in terms of risk reduction. Risk assessment therefore provides a useful starting point to prioritise action. It should also inform the design of any remediation strategy or decisions about the use of land – the main component of risk management (this is where the work of CARACAS ended and CLARINET began).

The risk assessment may concentrate on the current use of the site, which can be described as a "land use-related risk assessment", and will provide information to

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[48] FERGUSON *et al* (1998)

[49] CARACAS – Concerted Action on Risk Assessment for Contaminated Sites in Europe: http://www.caracas.at; CARACAS was the predecessor project to CLARINET

decide whether remediation is necessary to reduce or eliminate risk to the current users or the ecosystem.

However, remediation of contaminated land may be carried out not just to reduce risk related to the current use. The remediation of *brownfields* is motivated by the need to create a new use of the land safely, driven by spatial planning considerations or to conserve greenfield sites, and to a much lesser degree by immediate human health or environmental risks.

Risk assessment is an expanding science. It can only rely to a limited extent on observed effects to provide firm evidence. It must include an element of prediction, based on a sound understanding of the behaviour of contaminants and their effects, and on robust concepts underlying any theoretical modelling of future impacts.

CARACAS concluded that the current approach to determining the level of risk is a loose assemblage of building blocks borrowed from different scientific fields, rather than an integrated approach built from first principles[50]. The core components of the sequence of sampling, exposure modelling and toxicological evaluation need further refinement and better integration. This will also assist in identifying and managing uncertainties in the assessment.

5.1.2 Expanding the approach

CLARINET explored the possibilities for further development of risk assessment techniques to create a risk-based management tool for contaminated land. To assist fully in risk management, risk assessment must go beyond the assessment of the situation before remediation and consider the risks during and after remediation, often for different endpoints or different uses of the land.

Broadening the scope of risk assessment from a diagnostic tool to a management tool for the design of contaminated land solutions is not straightforward. New scientific questions may arise concerning issues such as the comparison of risks from a range of remedial options, the acceptability of residual risk, and risk ‘ownership’ and transfer over long time periods. These additional uncertainties will need to be addressed in a transparent way in the decision-making process. They involve economic and social considerations as well as environmental ones.

The use of risk assessment as a management tool is illustrated by a comparison of four proposals for remediation strategies for the Bitterfeld area in Germany, prepared by consortia from different EU countries. The proposals were analysed by CLARINET with support from experts from the NICOLE network and presented at the CONSOIL 2000 conference. The work is summarised in *Box 5a*.

The comparison of proposals for the Bitterfeld area clearly demonstrated the strengths and weaknesses of risk assessment to predict the situation after remedial

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[50] see Chapter 9 "Better methods of risk assessment" in FERGUSON *et al* (1998)

action. The proposals where also very different in their use of risk assessment during the planning of remedial actions but remarkably similar in the proposed solutions.

Box 5a: "Comparing four remedial plans for the contaminated Spittelwasser floodplain"

The idea that the results of contaminated land remediation would be more similar than the underlying national policies might imply, has always been considered as an interesting statement to test in practice. The organisers of the CONSOIL 2000 conference invited four national consortia to make remediation plans for a single European site, in order to investigate this idea. The plans had to be based on the prevailing national approach in the country of origin of each consortium.

Teams from Denmark, Germany, the Netherlands and the United Kingdom participated in this “CONSOIL case comparison project”. They were asked to describe their national approach and to provide a solution for the heavily contaminated Spittelwasser floodplain in the region Bitterfeld–Wolfen accordingly. The Spittelwasser is a creek which is the most important tributary of the river Mulde in the Bitterfeld district. Due to the intensive former industrial activities in the Bitterfeld district, the sediments of the Spittelwasser became loaded with contaminants, especially dioxins. Due to frequent flooding, the river banks and the surrounding land (flood plains) are highly contaminated. Contaminated sediments are transported downstream to the river Mulde and may in the end reach the North Sea via the river Elbe. The Concerted action CLARINET[51] was asked to review the proposals and to highlight similarities and differences. The CLARINET steering group invited representatives from NICOLE[52] to participate in the assessment of the plans.

CLARINET decided to use the concept of ‘risk based land management’ (RBLM) as a yardstick to compare the plans.

All remediation strategies proposed were indeed risk based and took land-use into consideration. The solutions are to a large extent in line with CLARINET’s RBLM concept. They also pointed in the same direction and would have yielded similar results. However, they differed in emphasis on risk assessment, risk management and integrated solution design. So it seems that policy and tradition may influence the way plans are made and the way the choices are motivated, but the remedial solution itself seems to be almost exclusively determined at the practical and technical level, and not by national policies.

The effect of differences in contaminated land policy is more conspicuous however, in the problem definition stage (risk assessment to substantiate the need for remedial activities) and in the final results of the remedial action, in specifying in quantitative terms the quality of soil and groundwater that must be achieved in relation to land use. The solution finding phase, which lies in between the above methodological stages, was the main subject of the plans for the Spittelwasser area and seemed to be less dependent on national policies.

Reference:

CONSOIL (2000): *Bitterfeld/Spittelwasser Site Case Study*. Presented at the 7th International FZK/TNO Conference on Contaminated Soil. Leipzig-Halle, Germany.

[51] CLARINET: Contaminated Land Rehabilitation Network in Europe (further information http://www.clarinet.at)

[52] NICOLE: Network for Industrially Contaminated Land in Europe (further information http://www.nicole.org)

5.2 Determining the level of risk

5.2.1 Human health risk assessment – a staged approach

Current human health risk assessment good practice is built around a staged approach. In the first stage, concentrations of contaminants in soil, groundwater and other media can be compared with generic guideline concentrations, which use general assumptions about the conditions of the site and the receptors. These usually make the generic values conservative, as the assumptions are deliberately cautious[53].

If the first stage assessment does not lead to a clear decision - either that there is no problem or that remediation is appropriate – the second stage of a site-specific risk assessment is used.

The second stage involves exposure modelling using site-specific data. This could mean the use of the generic model with modified assumptions, or it could mean the use of a different model if the site conditions or other parameters are very different to those in the generic model.

If the results of this second stage assessment are still not clear enough to make a decision, then a third stage may be needed. This can include further development of a site-specific model, or additional measurements on specific contact media (indoor air, home-grown vegetables, drinking water), or, in some exceptional cases, a survey of the health of people living at or near a site.

It will be obvious that the third stage (and some aspect of the second stage) may not be possible if the risk assessment aims to predict the risks after remediation using different remediation approaches. If remediation is actually carried out, the results of the assessment can be re-visited to establish if risk reduction has been sufficient.

5.2.2 Improving human health risk assessment[54]

Human health risk assessment involves the identification and quantification of *sources***,** the identification and measurement of *pathways*, the identification of *receptors* and the analysis of the sensitivity of the receptors to contaminants.

There are a number of pathways which contribute to the risk to human health, which depend both on the characteristics of the source and the behaviour of the receptor. For example, where the contamination is mobile in the soil and has caused pollution of ground and surface water, there is a potential pathway to human health through the ingestion of contaminated drinking water.

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[53] see Chapter 2 "Fundamental concepts of risk assessment" in FERGUSON *et al* (1998)

[54] more detailed recommendations are provided in Chapter 9 "Better methods for risk assessment" in FERGUSON *et al* (1998)

Different pathways can be managed in different ways. In the case of the water pathway the risk is often prevented by control of drinking water quality – for example by providing treatment - before it is allowed to enter the water supply. This provides a way of managing the problem identified in the risk assessment, although, as discussed in Chapter 3, it does not necessarily lead to the most sustainable long-term solution.

Experience has shown that apart from direct consumption of groundwater for drinking water purposes, at the moment three other pathways tend to dominate the contribution to exposure of people to soil contamination, each of which has specific problems for the risk assessor:

- soil ingestion;
- consumption of vegetables grown on contaminated land; and
- inhalation of volatile substances emanating from soil into indoor air.

Soil ingestion

Calculation of soil ingestion is a simple concept, involving the amount of ingested soil and the bioavailability of contaminants in ingested soil as important variables. However, while there is now reasonable consensus about soil ingestion rates, bioavailability is still largely unknown.

Conservative approaches would assume that the bioavailability of contaminants in the soil matrix is similar to their bioavailability in food or – even more conservatively – in water. However, using this type of assessment in areas with higher background concentration, where no adverse health effects are observed, can lead to an unsatisfactory conclusion for decision makers: an apparently high risk has in fact no observable effect on human health. It is clear that bioavailability is a major factor in this, but what is not clear is to what extent it should be adjusted.

This means that risk-based decisions in this case are difficult, if not impossible, to make. There is therefore an urgent need for the development of methods to assess the bioavailability of substances in ingested soil. The BARGE research network was created by CLARINET to address this issue. Details of this project are given in *Box 5b* below.

Consumption of vegetables and other pathways

The other important pathways are more complicated because they involve a number of steps. Total uncertainty will increase due to the uncertainties associated with each step in the exposure route. A reliable quantification of risk may become more difficult. Consumption of vegetables grown on contaminated land can only lead to exposure if vegetables take up or otherwise contain the contaminants, and this is difficult to predict accurately. However, this has less significance for risk management, as vegetable crop quality from commercial agriculture is usually regulated in any case, and the consumption of contaminated home-grown vegetables can in theory be avoided as a fail-safe option.

For practical risk management purposes, uncertainties in exposure from vegetable consumption are therefore of lesser concern than uncertainties in exposure from the inhalation of indoor air. Unfortunately, the latter route is the most difficult one to assess. Uncertainties in model prediction are huge and reliable measurements of concentrations in indoor air are very difficult to obtain.

Box 5b: BARGE - the BioAvailability Research Group in Europe

Ingestion of soil is a dominant exposure route for humans. 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.

In December 1999 the need for co-operation and / or exchange of data on oral bioavailability for soil contaminants was investigated under CLARINET. The need for co-operation appeared to be strong, and a great enthusiasm to exchange knowledge between countries was evident. Hence, the BioAvailability Research Group Europe (BARGE) was founded.

The participants agreed to compare the five existing *in vitro* digestion models by using three identical soil samples each containing three contaminants (As, Cd and Pb) in a “round-robin” experimental set-up. The results of the round robin revealed diversity in bioaccessibility values for the same contaminant and soil, strengthening the need for greater understanding of the driving forces behind these differences. The main differences in bioaccessibility values can be explained on the basis of the applied gastric pH in the various *in vitro* digestion models, which correspond to different physiological conditions, i.e. fed and fasted state.

Research via BARGE appears to be an efficient way to enhance the knowledge in this field within a limited time frame and opens possibilities for the different countries to deal with the issue of bioaccessibility and oral bioavailability of soil contaminants in a similar manner.

References:

SCHELWALD R.A. (2001) BARGE, Bioavailability Research Group Europe: European Co-ordination on Risk Assessment of Soils; Land Contamination & Reclamation, 9 (1) pp. 107, EPP Publications. See also the BARGE Website at *www.schelwald.nl/pages/barge.*

Use of models

Irrespective of the large uncertainties in exposure modelling, the validation and verification of models are also important issues in development of guideline values and in site-specific risk assessment. The CLARINET working group on human health aspects therefore initiated an international comparison of exposure factors used in exposure assessment models and performed a comparison of predicted exposures by different national models, summarised in *Box 5c* below.

Box 5c: Human exposure comparison study
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. Therefore a better insight into the accuracy of exposure models is required. For this reason model calculations using different models from seven different European countries are 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).* Twenty hypothetical scenarios have been defined. These scenarios differ in respect to 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 from different groups, are considered to be common throughout Europe, and have different exposure characteristics. Results of these comparisons indicate that calculated exposures can vary substantially. 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.
References: SWARTJES, F. A. (2001): *Calculation Of Human Exposure – An International Comparison Of Exposure Model Variability;* Proceedings of final CLARINET conference, Vienna, 2001; available also at http://www.clarinet.at 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

At present it is clear that models need more validation to compare predicted results with field measurements. In view of the complexity of the soil and groundwater environment, the main focus of this would be on the “fate and transport” components, including the distribution of contaminating substances over the soil phases.

CLARINET strongly recommends further study and discussion of the underlying differences in models and on the ways of improving their predictive power. Validation by comparing model predictions with field measurements should precede international harmonisation of models. It is of course recognised that a complete validation of human health risk assessment models is not possible for ethical reasons. However comparing model predictions with epidemiological data may contribute to better modelling, and validation of the “fate and transport” components of the model still remains possible.

Use of epidemiological studies

Coupled with exposure assessment, specialist epidemiological studies, where the data quality is high, can potentially indicate a causality between exposure and health effects. The relevance and capabilities of a range of epidemiological tools and techniques were explored in a joint workshop[55]. This explored the fitness for purpose of a suite of tools for a set of case studies, and considered the strengths and limitations of the selected techniques.

The workshop concluded that good problem definition is an essential pre-requisite of any study, that tools must be selected that are suitable for the problem in hand, that improved interfaces were required between epidemiological tools and exposure assessment and that a wide range of stakeholders had interest in the design, execution and interpretation of these studies.

5.2.3 Ecosystem risk

Soil ecosystems are essential for life on earth. The living soil, which takes care of important processes like decomposition and nutrient cycles is the life support system for above ground nature, agriculture and other more “residential” landuses like gardens, parks and allotments. Soil life may also assist in the solutions for contaminated land problems via biological degradation of contaminants. Soil ecosystems are an important target in soil protection[56]. The relation between soil and groundwater contamination and soil ecosystem functioning is therefore an important subject in contaminated land risk assessment.

At present, the methodology used in human health risk assessment is generally regarded as more developed than its ecosystem counterpart. This is primarily a result of a lack of information about sensitivities of different species to contamination and a lack of knowledge about specific exposure mechanisms and about bioavailability.

However, the problem addressed in ecological risk assessment is also more complex. Species are the building blocks of ecosystems and may interact. Effects on one species may lead to effects on other species and on important ecological processes (decomposition, mineral cycling) to which species contribute. The interaction between species may result in ecological systems changing in unpredictable ways.

[55] Environment Agency for England and Wales & CLARINET (2001)

[56] EC Communication "*Towards a Thematic Strategy for Soil Protection*". COM (2002) 179 final

On the other hand, ecosystems have shown some “robustness” towards contaminant impacts. Ecosystem theory is not ready yet to make predictions about robustness or sensitivity on a site-specific basis[57].

Another complicating factor is that many ecosystems are already under pressure because of the way in which society uses the land. The starting point for ecological risk assessment of soil contamination is a system already quite different from an undisturbed natural one. This is especially the case in agriculture, where farmers modify parts of the ecosystem to suit their needs.

Current practice

Current practice in European ecological risk assessment is based on a number of increasingly established basic components. For example, the staged approach has been discussed at the CLARINET workshop, mainly as a diagnostic tool for a better assessment of site-specific ecological risks[58]. One of the difficulties is the need to distinguish between the effects of the contamination and the effects of other stressors on the ecosystem.

Overall, CLARINET established that while there are still difficulties in predicting the specific consequences to ecosystems of the presence of contamination, techniques are available and are being developed[59]. However, more significantly, the question of whether these consequences are acceptable or not, is largely unresolved.

The need for quality guidelines for soil going wider than human health risks has been suggested in a number of papers published on the CLARINET website[60]. It is difficult to say what level of ecological health or variation is needed for land uses, other than for specifically designated nature areas. Setting general guidelines will also face many of the scientific difficulties similar to the ones experienced in practice in site-specific ecological risk assessment.

The ecological aspects of contaminated land remediation can therefore still only be dealt with in rather pragmatic and qualitative ways, for example ensuring that:

- gardens have sufficient soil fertility;
- natural decomposition processes can operate;
- phytotoxic levels of contamination are avoided; and
- health issues of domestic animals and protected species are addressed.

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[57] see Chapter 4 "Receptors: ecosystem health" in FERGUSON *et al* (1998)

[58] CLARINET Workshop on Ecological Risk Assessment, April 17-19, 2001 Nunspeet, the Netherlands

[59] CLARINET stimulated the European research project LIBERATION on the sustainable management of contaminated land by linking bioavailability, ecological risk and ground water pollution of organic pollutants; see *http://www.liberation.dk/*

[60] *http://www.clarinet.at*

It is vital in all risk assessments to consider all the relevant receptors and to be aware of the level of uncertainty at any stage of the assessment. Sound risk based land management practice should anticipate the possibility that initial remediation may not achieve sufficient risk reduction, and provide for further stages of remediation. This may apparently lead to a more conservative approach overall but it can also lead to the development of more flexible and interactive strategies.

5.3 The issues at a European level

There is an increasing consensus amongst the wider scientific and other stakeholder community represented in CLARINET and its sister network NICOLE that the use of risk assessment should be an integral part of contaminated land decision-making[61]. However, regional and local authorities in a number of member states are still reluctant to use risk-based approaches. There are a number of reasons for this.

Awareness

The first is that authorities may not be aware of the current state of scientific knowledge, in particular of risk assessment methods and the way in which they can be used to improve transparency in decision making.

Ease of implementation

The second relates to the ease of control of implementation of policy decisions. Deciding whether concentrations of contaminants meet some fixed numbers set as the remediation criteria seems much easier than controlling the process of site-specific risk assessment and site specific risk management decisions.

A fixed number also appears to offer more “certainty”, so that stakeholders feel more confident in making their decisions. However, if a fixed number has been chosen arbitrarily (e.g. by taking numbers from other countries without considering their derivation), the risk may still be there, so the actual uncertainty is in fact greater[62].

The issue here is partly one of the way in which guideline values should be used, but also relates to the derivation of the values. It is vital that generic values are themselves derived in a structured and risk-based way, rather than on some arbitrary basis. The derivation should also take into account the regional circumstances so that the level of protection is the same, not the number.

CLARINET has provided a scientific briefing on the issue of numerical values for soil contaminants, which considered the types of numerical values, the different uses and their derivation. It concluded that without consideration of the factors which must be taken into account on a geographical basis, such as soil properties and human

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[61] CLARINET / NICOLE Joint Statement: *Better Decision Making Now*. October 1998.

[62] see Chapter 8 "Screening and guideline values" in FERGUSON *et al* (1998)

behaviour, a fixed concentration for a contaminant would correlate to a significantly different level of actual risk in different places[63].

Skills

The third reason is the fear that authorities and others involved in solving contaminated land problems lack the attitudes and the skill to apply risk-based contaminated land management in practice. Indeed, risk based land management in general does require a change in regulatory culture. CLARINET feels that the change is justified by the benefits in term of quality of decision-making and the perspective of sustainable management of land and water resources.

More science will not change the regulatory culture, since the regulatory culture in turn must reflect what society – and all its different stakeholders - feels is the right approach. For example, without a raised level of understanding, the idea of a fixed number, however arbitrarily derived, will continue to provide a sense of reassurance that will only be threatened by more and more complex science.

The change from meeting increasingly fixed stringent standards towards flexible management decisions; involving site and region specific environmental, economic and social considerations, will not be achieved by a scientific revolution in isolation, but by a joint evolution of approaches. A permanent dialogue between scientists, policy makers and practitioners (local decision makers, problem holders and their professional advisers) is needed to achieve this transition.

5.4 The relationship to RBLM

RBLM tries to integrate environmental, economic and social issues in contaminated land decision-making within a long-term management framework. The three main elements of risk based contaminated land management - and in land management in general - are “fitness for use”, “protection of the environment” and “long-term care”.

Risk assessment is clearly a key issue in this. However, it should be noted that risk assessment in the narrow sense often addresses the physical domain only and ignores the economic and social domain. This needs to be recognised in contaminated land decision-making. ‘Risk based’ does not mean that toxicity is the only justification for taking action.

Economic approaches are needed to assess the value of the components affected. Social analysis is needed to consider perception of risks, as well as values such as culture, or the intrinsic value of pristine environments, that are not easily translated in market value. It must also consider the impact of long term burdens.

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[63] CLARINET response to the *White Paper on Environmental Liability* presented by the Commission of the European Communities on 9 February 2000 (COM(2000)66 final).

5.5 The future

Risk assessment is an essential tool in managing contaminated land within the RBLM framework. It provides a structured and transparent approach for sound decision-making. It also provides the means to improve scientific and practical knowledge in a focused and structured way.

CLARINET recommends that further development and practical implementation of the RBLM framework is an important step in the direction of sustainable resource management (soil and water). Actions have to be taken on various levels, e.g.

- communication between various stakeholders about the practical implementation of risk assessment in the broader RBLM framework;
- identification of priority RTD needs and co-ordinated research activities for improving existing risk assessment methods and techniques and subsequent application of the achieved knowledge for solving actual contaminated land problems;
- focussed education and training at academic and practical level.

A number of initiatives have been already started to improve knowledge and shared understanding of risk assessment approaches in Europe. CLARINET recommends that these initiatives should be increased by national EU policy makers for developing and implementing appropriate risk based approaches. This transition process can be facilitated for example through international networks and discussion platforms.

Co-operation and information exchange will provide a clear vision on the balance between scientific harmonisation of risk assessment practice on the one hand, and the need to retain appropriate national and local approaches, on the other hand. The former will clearly help to focus research and avoid duplication. The latter will ensure that this does not go beyond harmonisation and create an imbalance in actual levels of protection in different circumstances.

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CHAPTER 6 FINDING BETTER SOLUTIONS

"… in every case they made the ground to suit their plan,
and not the plan to suit the ground."

Mark Brunel

The previous chapter discussed the role of *risk assessment* in providing an objective, scientific evaluation of risk to health of humans and ecosystems and to environmental resources in the context of risk based land management. This chapter focuses on the process of finding and implementing better solutions. This completes the overall process of *risk management*.

At the general level, the remediation of contaminated land supports the goal of *sustainable development* by preventing the spread of pollution to air, soil and water, conserving or enhancing the quality of land as a resource, and as a result reducing the pressure for development on greenfield sites. It can also remove pressures on society, particularly in relation to direct impact on quality of life.

However, remediation activities themselves have their own environmental, social and economic impacts. On both an overall level, and a project-by-project basis, the negative impacts of remediation should not exceed the benefits, and any side-effects need to be considered.

Risk based land management aims to take forward the three components - fitness for use, protection of the environment and long-term care - into the operational level of day to day decision making.

At this practical level, one of the key factors in decision-making will be the nature of the **drivers**, or initiating factors, for any particular remediation project. It is clear that the drivers for remediation on a particular site come from the need to:

- Protect human health and the environment on newly identified contaminated land;
- Repair previous remediation work where past risk management has been inadequate;
- Enable redevelopment;
- Increase land asset values;
- Limit potential liabilities.

Each of these drivers will have different influences on the nature of decisions about remediation. The key factors relevant to the implementation of RBLM in practice - as set out in Chapter 2 – are also relevant.

Applying a RBLM approach in decision-making aims to ensure that the decisions consider the long-term social, environmental and economic impact to achieve **sustainable development**.

6.1 Why better solutions are needed

At present, the solutions available for contaminated land management have largely concentrated on the narrow aspects of solving the contamination problem and finding the costs of the solution. There is a danger that this narrow scientific approach may distract decision makers from seeing the wider issues for sustainable solutions. The Risk Based Land Management concept enables a wider perspective in both a spatial and temporal basis by balancing the three main components - fitness for use, protection of the environment, and long-term care.

Without considering this wider perspectives in decision making, selected solutions may create problems in the future. It is also possible that the opportunity to develop and – more importantly - to implement enhanced solutions will be missed. In the long term, a narrow approach will leave a continued legacy of problems for future generations.

It is essential to develop a sound scientific basis for understanding the technical solutions and to gain practical experience from their effectiveness, costs and limitations. One of the key issues is to understand the way available technologies can be used, and have been used, in different applications and contexts[64]. CLARINET has provided a detailed review of available remediation techniques (excluding conventional containment and removal to landfill approaches) and carried out a survey about the technical implementation of remediation technologies in European countries[65].

6.1.1 Decision support tools

A number of interacting considerations are relevant to finding sustainable technical solutions for contaminated land problems. An integrated approach to deciding which risk management option(s) are most appropriate for a particular site is essential. These decisions should also be made in a structured and transparent way.

However, decision support techniques or tools (*DST*s) are in their infancy. CLARINET has provided a detailed review of decision support tools used in Europe for selecting technical solutions[66] and established an initial on-line catalogue of contaminated land DSTs[67].

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[64] NATO/CCMS Pilotstudy on Evaluation of Demonstrated and Emerging Remedial Action Technologies for the Treatment of Contaminated Land and Ground Water (Phase III): *http://www.nato.int/ccms/*

[65] Clarinet Report „*Remediation of Contaminated Land. Technology Implementation in Europe - State-of-the-Art*” (2002)

[66] Clarinet Report „*Review of Decision Support Tools and their use in Europe*” (2002)

A wide variety of decision support tools, from simple procedures to software based tools, continue to be developed covering a range of applications from site investigation support to cost benefit analyses. However, the need remains for decision support techniques to:

- Consider sustainable development and risk management in an integrated way; and
- Support stakeholder engagement in a way that is robust and transparent, even to non-specialist audiences.

6.2 The issues at a European level

A survey of decision support issues in different CLARINET countries[68] found that the basic approaches for evaluating and managing contaminated land problems have a similar structure. For example, there is consensus on the key decision support stages for contaminated land management on a project by project basis, as follows:

- Problem identification (including historical assessment and as a result the identification of potential sites);
- Problem investigation and determination of the need for remediation;
- Risk identification (actual and potential);
- Detailed risk evaluation and the identification of the remediation goal;
- Selection and implementation of remedial measures;
- Monitoring of sites following remediation and aftercare.

With this consensus on the overall strategy there is some availability of DSTs to bring this strategy into practice. However, the overall position is still a rigid approach with little interlinking between stages. More flexibility would lead to a wider range of choice of solutions and a more efficient result. However, there are barriers to the development of this greater flexibility.

6.2.1 Barriers to new solutions

In many countries, authorities and practitioners see decision-making as seeking a balance between “cost” and “benefits”. Financial resources are limited, so remediation work must show a clear balance of benefits over costs.

Structured decision support tools for considering sustainability both for remedial objectives and for remediation work in a holistic sense have yet to emerge, either in written or software form. A number of analytical tools, such as Life Cycle Analysis

[67] available at http://www.clarinet.at

[68] Clarinet Report „*Review of Decision Support Tools and their use in Europe*” (2002)

(LCA)[69] and Multi-Criteria Utility Analysis (MCA)[70], are beginning to be used to consider wider environmental benefits. Less work has been done on providing tools for considering the social and economic aspects of sustainable development for remediation.

Priorities for environmental protection, including contaminated land policies, are affected by the way industrial development has taken place in different regions, together with differences in available resources and social circumstances. However, while there is considerable awareness of the need to address issues of sustainability, only very few projects consider this principle explicitly in the decision-making processes.

Another problem is that both the decision support tool and the solutions themselves are not necessarily always acceptable to all of the stakeholders involved with a contaminated land project. Some stakeholders can see DSTs as "obscure" or not "validated in terms of effectiveness", or do not accept the basic underlying parameters. These difficulties may be greater when *lay*[71] stakeholders become involved in decision-making.

The CLARINET review of available technologies[72] also identified gaps in scientific knowledge and barriers to the development and commercial implementation of new promising solutions. These gaps and barriers may inhibit the development and implementation of a wider range of sustainable solutions, and include:

- time constraints;
- legal constraints;
- lack of confidence in achieving acceptable remediation;
- cost effectiveness;
- market interest.

Time constraints

The dynamics of city renewal and large building projects dictates the time frame for many remediation projects. Contamination is seen as a first hurdle to be removed as fast as possible. Time constraints may also result from regulatory pressures, for example where a serious environmental impact from contamination is suspected, solutions needs to be effective quickly. These circumstances may result in remedial solutions based on excavation and removal.

[69] A technique for evaluating the broad environmental impacts of producing consumer goods

[70] A structured system for ranking alternatives and making selections and decisions

[71] "Lay" describes those who do not have a role related to the specialist contaminated land professional or administrative activities in the project.

[72] Clarinet Report „*Remediation of Contaminated Land. Technology Implementation in Europe - State-of-the-Art*" (2002)

However, more recently there has been increasing use of *in situ* approaches whose operations continue in parallel with site redevelopment and re-use. This requires more flexibility in planning of future land-use allowing for source control and pathway management interventions to take place during city renewal and building projects. Removal off-site remains a common choice for remediation where cost, time and technical constraints limit effective *in situ* choices.

Legal constraints

Regulatory burdens can represent a disincentive to use alternative techniques. In some countries waste-licensing requirements inhibits the use of on-site solutions, in others the development and use of off-site facilities.

Uncertainty concerning future liabilities, e.g. resulting from stricter regulations or the detection of “new” contaminants, discourages technologies which leave residual contamination in the ground on a risk based approach.

Lack of confidence in achieving acceptable remediation

When remediation targets are set, the solution must provide confidence that these objectives will be met. These remediation targets are often based on different combinations of total concentration, soluble concentration or bioavailable concentration, which can be critical for different technologies. For example, technologies removing bioavailable contaminants (e.g. phyto-extraction) tend to increase the availability of contaminants. This may be considered as a risk for the environment. There is also a lack of confidence that remaining non-available contamination will remain in that state forever.

There is also a lack of generally accepted procedures for verifying that the remediation technology has worked. There may be difficulties in making measurements for *in situ* approaches; concerns over the general reliability of sampling and analytical procedures; understanding the significance of stabilised contaminants (e.g. how to link performance to changes in bioavailabity over time).

Performance information is not always easily transferable between Member States. Approaches to control and monitoring of processes and end points for remediation varies throughout Europe. Hence what constitutes a validated performance record in one country is not necessarily persuasive to stakeholders in another country. While, an increasing use of risk management tools is leading to a common basis for decision making, differences in the implementation of risk management, cost structures, and "non-technical" perceptions of differences between countries still tends to mean that remediation data often are not directly transferable between countries. However, a common European framework for the demonstration of remediation technologies, which would ease technology transfer between countries, will be difficult to develop because of the differences above.

Cost effectiveness

The risk manager – or other stakeholders – is often not convinced that new solutions will be effective and economic. In general there is insufficient information to reassure the market that innovative technologies can be viable. Although the market situation is becoming more positive for in-situ and other innovative remediation technologies, this positive development should be stimulated by knowledge transfer and innovation management policies.

Across Europe the costs for the same technology can vary by several orders of magnitude. This may reflect the different economic basis for environmental work, and particularly the support for implementation of innovative technology. The cost of delivering contaminated soil to landfills varies throughout Europe. Where it is cheap there is limited incentive for alternative approaches.

Market interest

The market does not necessarily see that preventing the use of green field land is an economic option. This means that the value of a new development on a brownfield land does not always attract a premium to encourage more clean up, and in turn more solutions.

6.2.2 Acceptability to stakeholders

While the 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[73]. For example, local communities may not accept a risk basis for decision making, possibly because it has not been explained adequately, possibly for other reasons - for example they want “zero risk”. This perspective is not unlike that of many prospective purchasers of contaminated sites, or companies considering inward investment.

CLARINET recommends involving all relevant stakeholders at the earliest possible stage of decision-making. However, this may be a hard choice, because any decision support must not hamper efficient and cost effective decision-making or cause excessive delay. A major concern of core stakeholders is that, by widening their considerations and their consultees, they run the risk of bringing the decision making process to a halt; or making it so difficult that, for instance, brownfield remediation becomes less attractive.

As a result, the major challenges for improving contaminated land decision making in the future are not only harmonising decision making criteria to reflect the more holistic approach of RBLM, but also to make them practical and relevant to a wider range of stakeholders.

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[73] NICOLE (2001)

6.3 The relationship to RBLM

The interface between RBLM and the development and selection of solutions to contaminated land problems is discussed below, first by using the key components to identify issues, and then by examining the aspects of RBLM in practice.

6.3.1 Fitness for use

In the context of RBLM, "fitness for use" describes primarily the relationship between different envisaged uses for a site and the risk management action necessary to limit risks to a level that is acceptable (or better) for that envisaged use.

Most countries have now produced decision support systems, in the form of guidance, for setting risk management goals for sites, based on the concept of "fitness for use". In some cases, software based tools (from commercial providers or public sector agencies) are available to support individual steps or a series of steps within this guidance.

From a project standpoint, remediation works also need to achieve "*fitness for purpose*" which is wider than *fitness for use* and includes other conditions. For example, the site should be capable of supporting the engineering works and buildings on it, there should not be unmanageable obstructions to services or to groundwater flow, and wider considerations relevant to the viability of the site may apply, for example that the appearance of the remediated site is acceptable.

6.3.2 Protection of the environment

Treatment technologies aim to protect the environment and often to restore a resource. However, they need to be evaluated themselves in terms of any harm or pollution they may cause, and in terms of safeguarding resources.

In many cases, risk management goals are considered in advance of any detailed consideration of the wider environmental, economic or social consequences of the remediation work. These wider consequences have usually implicitly or explicitly been considered to be trivial compared with the benefit of achieving the remediation goals, particularly as process emissions - for example emissions of volatile organic carbon compounds (VOCs) to atmosphere - will usually be controlled by licensing or other similar pollution prevention and control (PPC) regulations.

However, the consideration of these wider consequences, including any side effects of the remediation, is becoming increasingly important: first, because of general sustainable development policies, and secondly because of a desire to be able to demonstrate appropriate use of resources and value for money.

A number of projects in Europe, for example in the Netherlands, Germany, the UK, Denmark and Switzerland have suggested approaches to considering the wider environmental impact of remediation work. The CLARINET Report „Review of

Decision Support Tools and their use in Europe" reviews several examples as case studies.

6.3.3 Long-term care

Formal decision analysis could provide a mechanism to evaluate the balance of longer-term aspects against short-term issues for different remediation approaches for particular problems. A number of DSTs have been developed that try to address these questions[74], for example:

- Procedural guidance on cost benefit analyses for aquifers and for contaminated sites from the UK (Environment Agency 1999 and 2000);
- The Dutch REC model (NOBIS 1995 a and b);
- The WILMA model in Germany (Weth 2000).

While DSTs like these can certainly assist the evaluation of different options by informed practitioners, the state of the art is such that they require careful use, especially related to transparency, lack of objective judgement, lack of validation, and lack of broad stakeholder involvement.

6.4 RBLM in practice

6.4.1 Risk reduction – timeframe and choice of solution

As discussed in Chapter 2 of this report, the two key decisions in RBLM are the **time frame for remediation** and **the choice of solution**. These are interdependent and have a strong effect on both risk management, decision-making and its implementation. This is partly because the range of available solutions is usually critically dependent on the time available for the risk management to become effective, but also because certain solutions may offer the opportunity to look more flexibly at the timeframe.

Timeframe

In some cases, the overall decision with regard to the available time frame is that treatment is not immediately necessary, but will be in the future. For example, an industrial site owner may be aware of contamination on site that does not pose a problem under its current use, but would prevent his site being sold in the future for other uses. In this situation, there may be an opportunity to apply long-term treatment solutions to return the site over time to a condition suitable for other uses.

The technical solution itself can buy time for a more complete environmental solution. For example:

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[74] Clarinet Report „*Review of Decision Support Tools and their use in Europe*" (2002)

- Containment (for instance by hydraulic or barrier means) may provide an immediate risk management effect, which can obtain more time to achieve a permanent risk management solution.
- Restricting the end use of the site for a fixed period can manage the risk until a long term and permanent solution becomes effective. The site does not have to be barren to achieve this. For example, short rotation coppicing[75] using added organic matter (e.g. from waste derived sources) could generate income and reduce risks over time. This kind of approach may be particularly appropriate for large areas of denuded and derelict land, whose very scale makes more immediate or conventional risk management solutions impossible.

The aim is to provide an optimal balance of managing risk, maximising wider environmental benefits and limiting burdens.

Choice of solution – dealing with source, pathway or receptor

As discussed in Chapter 2, one factor in choosing a solution is to consider the underlying basis of the risk, in particular the *source-pathway-receptor* mechanism considered in risk assessment. Risk management techniques can apply to any one of the three components, but each will result in a different impact on the three components of the RBLM concept *(see Box 6a).*

Current practice shows a preference for a **source-oriented approach** if this is practicable. This may involve removal of contamination (either together with the matrix in which it is found, such as soil, or by extracting it from the soil and/or groundwater) or degradation or other change to the intrinsic characteristics of the contamination.

This approach can ensure *fitness for use*, and, if it is complete in its removal of the source, eliminates the need for *long-term care*. However, it may be difficult to predict the actual effectiveness. There may also be negative consequences such as risk to the environment during the process (e.g. damage to an ecosystem) or use of resources such as energy or raw materials, or transfer of the problem to somewhere else.

Pathway control techniques modify the way in which contaminants can reach the receptor. One method is to place a “simple” physical barrier, such as a bentonite slurry wall or a capping layer, between the source and the receptor. Other methods include containment through groundwater pumping (and treating) and "active containment", for example reactive barriers for the removal of certain contaminants from groundwater flows.

These containment methods may have consequences for the use of the land, for example restrictions on use, or the presence of monitoring installations. It is in theory also possible to change the availability[76] or accessibility[77] of the contamination, but it

[75] Growing small trees which are regularly cut for use

[76] Availability, in the context of treatment processes, describes the ease of liberation of contamination within the treatment process.

requires a detailed knowledge of the current and future behaviour of not only the contaminants but also the ground. It is also possible to restrict the use of the land to avoid some pathways.

Whilst *pathway control* can achieve *fitness for use* and adequate *protection of the environment*, any risk assessment needs to take into account the possibility of failure of the pathway control methods and the approach has *long term care* implications.

Removal or management of receptors is also possible but rarely applied as a sustainable long-term solution where the receptors are already present on or near the contaminated land. For risks to human health, this would imply the evacuation of the site, which is only a realistic option in emergencies or where the practicalities of removing the source or controlling the pathway make any other solution unviable.

Box 6a: Source-pathway-receptor management

Risk management assists remediation by providing the rationale for employing different types of solution in a strategic way, such as

- *Source control* (removing, destroying or possibly stabilising the contamination source);
- *Pathway management* (preventing the migration of contamination along a pathway by either restricting the flow of air or water, or be removing contamination along this pathway);
- *Receptor management* (e.g. controlling the range of end uses for a site).

Often, conventional civil engineering approaches have formed the basis of the remediation of contaminated land. Excavation and removal continues to be one of the most important means for removing the source of contamination, such as leaking tanks.

Excavation of source terms is not always feasible, for example where there are many source terms, where source terms are deep, or where they are dispersed in aquifers. In these circumstances risk reduction often has to rely on pathway management. Source control responses for these circumstances include various extraction technologies using groundwater pumping, application of heat, high vacuum, sparging. For DNAPL's in particular[78] these tend to offer an incomplete solution, because mass removals are not sufficient to significantly reduce groundwater contamination, and indeed may enhance it by increasing the flux of dissolving contamination from residual source term. There is increasing interest in the possibilities for destructive (biological or chemical) rather than extractive techniques for saturated zone treatment at depth. Extractive solutions (such as air sparging) may well be more effective for shallower aquifers.

Containment, using conventional civil engineering techniques to restrict groundwater flow, has been widely used as a pathway management tool. While its use is still common place, permeable reactive barrier technologies are increasingly regarded as alternative. The advantage of this technology (possibly combined with monitored natural attenuation) is that while contamination is removed from the pathway, the flow of groundwater is not significantly impeded. This avoids problems of ponding which often occur with conventional containment.

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[77] Accessibility of contamination, in the context of treatment processes, describes the extent of its contact with the treatment medium.

[78] TEUTSCH *et al* (2001)

If the remediation is taking place as part of a redevelopment, there may be more options for *receptor management*. This can include changing the type of use of the land, or adjusting particular layouts to ensure that critical receptors are not present on parts of the site. However, clearly management of the receptors in this way only achieves *fitness for* a lower standard of *use*, and leaves restrictions on the subsequent use of the land as a long-term resource.

If the receptor is a *drinking water resource*, it is technically possible to move the extraction well or choose to treat the extracted water. These imply acceptance of some level of adverse effect on a receptor, and may not meet either the requirements for environmental protection either in terms of prevention of harm or pollution or of conserving resources. Similar arguments apply to permitting any adverse effect on other receptors.

Choice of solution – practical considerations

A further consideration in choosing a solution is whether the approach is practicable. A practicable technique meets the technical and environmental criteria for dealing with a particular problem.

The issues that affect the practicability of a remediation technology are:

- The context of risk management application – is it a site still in active use, or is it a site which has unrestrained access;
- The particular contaminants and materials to be treated ;
- The remedial approach itself - can it be used for the constraints of a particular site, for example based on its space requirements;
- Where remediation is to take place (*on site*, *off site*, *in situ*, *ex situ*);
- The overall strategy to be employed - for example combinations of different techniques may be used;
- How the remediation work needs to be implemented - the management requirements, including permitting, quality assurance and verification etc;
- The result of the remediation approach used – for example are contaminants destroyed, extracted or removed in some way, or stabilised or contained somewhere on site;
- How the resulting land condition interacts with the proposed land use – for example are the geotechnical properties of the resulting soil material affected.

6.4.2 Costs

Chapter 2 discussed different types of costs which may apply to a remediation project and the role of cost-benefit analysis. In order to make a final decision the costs need to be quantified, and made more efficient if possible, and the overall cost effectiveness of the solution needs to be evaluated.

Quantifying costs

Some of the costs are difficult to quantify and compare. As an example, it can be complex to make a direct comparison between the overall costs of solutions which take effect immediately and others which require a longer time frame. The first may have fixed "process" costs, whereas the other may require investment in terms of space, time and monitoring.

Cost efficiency

Correct identification of costs makes it easier to focus on ways of using money more efficiently. The public and private resources for contaminated land management are limited – they come from a finite overall budget and increasing them may simply mean removal of money from other deserving problems, or might result in failure for the businesses concerned. Dealing with risk management problems therefore needs to be prioritised, not only so that the most urgent solutions are dealt with first but also that the most effective outcome is achieved for the use of the limited resources.

This can be done by reducing the overall costs, for example by looking at ways of improving process efficiency or making the scale of the operation more economic. Another option is to get better value from the same level of expenditure, by trying to maximise the benefits. The greater the amount of time available for remediation, the greater the range of possible solutions, and the greater the feasibility of lower cost (long term-) solutions. The implications of this are that, over time, more sites can be dealt with for the same money.

Cost effectiveness

The cost effectiveness of the solution depends on the balance of costs and benefits**,** which in turn depend on the negative impacts or positive outcomes of each solution. The impacts or outcomes are likely to vary on a site-by-site basis. Impacts include the effect on human health, or on the environment, including resource use. Outcomes reflect the project drivers and the stakeholder concerns. For example, they can include a desired end use of the site, or a certain level of risk reduction to protect the environment or reduce liabilities.

6.4.3 Involving stakeholders

The *stakeholders* at the core of the decision making process for site remediation are typically the site owner and / or polluter, whoever is being affected by contamination, the service provider and the regulator and planner. However, other stakeholders can also be influential, such as:

- Site users, workers (possibly unions), visitors;
- Financial community (banks, founders, lenders, insurers);
- Site neighbours (tenants, dwellers, visitors, local councils);
- Campaigning organisations and local pressure groups;
- Other technical specialists and researchers.

Stakeholders will have their own perspective, priorities, concerns and ambitions regarding any particular site. The most appropriate choice of risk management approach will offer a balance between meeting as many of the “stakeholder needs” as possible, in particular risk reduction and achieving sustainable development, without unfairly disadvantaging any individual stakeholder.

It is possible that a proposed solution may be appropriate in risk reduction terms, technically suitable and cost effective, but not accepted by some or all stakeholders because of more subjective or non-technical factors. These include:

- Fixed preferences of stakeholders (for example a view that contaminated materials must always be dealt with *off site*);
- Lack of confidence in the technique, which may be affected by concerns about its previous performance, the adequacy of its validation, the expertise of the provider or the ability to verify its actual performance;
- The absolute cost, which may be more than the project can economically afford;
- The resulting timeframe, which may be critical for certain projects, such as brownfield site redevelopment to provide a new use quickly.

Clearly, confidence building, communication and negotiation are critical in developing a wider understanding and acceptance of solutions. Further work is also needed to overcome the remaining barriers to find appropriate and affordable solutions.

6.5 The future

CARACAS, CLARINET, NICOLE and other international initiatives have been a major cause of the emerging consensus about solutions for contaminated land management. These international networks have also been instrumental in transferring expertise and ideas between countries.

While CLARINET has established strong foundations, there is a long way to go yet in ensuring robust, reproducible and accessible solutions for sustainable contaminated land management. These solutions need to be transferred efficiently to all practitioners in contaminated land management, and be understandable to a wide range of stakeholders.

The adoption of risk based decision making will undoubtedly help to reduce the costs of contaminated land management, as well as provide more practical and robust solutions. However, their effective use requires detailed knowledge, e.g. of site characteristics. A cost conscious client community and strong competition between service providers combine to drive site investigation and remediation process costs down. A strong regulatory input is needed not just in the derivation of procedures and benchmarks, but also in ensuring the quality of risk management decision making.

It is also clear that, while there has been increasing interest in risk management strategies (including *monitored natural attenuation*) in the "technical" community, many lay stakeholders have grave reservations about approaches which seem to leave some contamination in the ground. Therefore, the objective and efficient dissemination of knowledge to a wider stakeholder community is an essential task for the future.

Different requirements in licensing remediation technologies between European countries are hindering the use of innovative solutions. Joint work between countries may help to resolve bottlenecks.

Information exchange about the technical performance of innovative technologies between European countries, combined with joint demonstration projects and benchmarking of technologies and techniques, may increase confidence in new approaches. A European certification system for remediation technologies (similar to the ESTCP programme performed in US[79]) would substantially increase the confidence into the reliability of innovative environmental technologies.

Considering the true contribution of remediation work to sustainable development of modern society in harmony with the environment is an emerging challenge. The development of risk based land management may profoundly change the way we manage contaminated land in the future.

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[79] ESTCP - Environmental Security Technology Certification Program; see *http://www.estcp.org/*

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CHAPTER 7 TOWARDS A EUROPEAN RESEARCH AREA

"We know more about the movement of celestial bodies than about the soil underfoot."

Leonardo Da Vinci, circa 1500's

"Science is organised knowledge."

Herbert Spencer

Research underpins the implementation of an efficient Risk Based Land Management approach. Politically acceptable decisions must be based on solid scientific knowledge and a comprehensive understanding of the environmental, economic and social aspects of the specific problems under consideration.

The Risk Based Land Management concept (RBLM) offers an overall framework for the implementation of integrated research initiatives. This requires a multidisciplinary approach and the formulation and peer review of ideas in close cooperation with a range of stakeholders to produce realistic and effective solutions. It also provides a focus for the transfer of research results into practical applications.

This chapter describes CLARINET's work towards a European research area on RBLM by identifying research priorities, stimulating research solutions, and looking at longer-term collaboration at a European level for national and international RTD programmes.

7.1 Research needs for RBLM

Most problems perceived with contaminated land[80] cannot be solved by technology alone. Experiences show that remediation of all soils and sediments by rigid technical means without considering related side effects is not a solution which follows the principle of sustainable development. Existing knowledge and techniques in environmental management have to be further developed to increase the range of possible solutions for perceived contaminated land problems. These solutions must also match the overall socio-economic context of the European Member States.

To achieve coherent solutions, science, technology and environmental management have to work in concert. Future research should therefore focus on the further development of management strategies addressing:

- ***ENVIRONMENTAL ASPECTS*** - The identification and analysis of pollution and its impact on human health, water resources and other environmental receptors.

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[80] The term "land" in the RBLM context includes soil and groundwater

- ***ECONOMIC ASPECTS*** - The relationship between soil and water contamination and land use to specify the conditions for sustainable land-use in urban and rural areas.
- ***SPATIAL PLANNING ASPECTS*** – Anticipation of future landuse changes that may affect the release of pollution; registration of land use restrictions due to contamination or long term cleanup activities; integration with planning of water use and river management.

These aspects are related to the key elements underpinning sustainable development (environmental, economic and social factors), and their further investigation will assist in balancing the RBLM components fitness for use, protection of the environment and long-term care at a strategic level.

There are various areas where coherent research would improve and advance the use of risk-based methodologies at a site-specific level. Each of the CLARINET working groups has considered detailed recommendations related to its own aspect of the problem. Among others, the following key areas can be identified[81]:

- The appropriateness of sampling regimes used, reconciling optimisation of information collection with rapid decision making for remedial actions;
- Reliability of contaminants data and assumptions, because environmental effects depend on speciation and spatial temporal effects (rather than "total" concentration) and on reliable identification / characterisation of pathways;
- Exposure assessment and toxicology (e.g. mineral and chemical speciation, human bioavailability of ingested contaminated soil, sorption effects and residence time in the body);
- Pollutant fate and transport models (e.g. interaction and fate of contaminant mixtures);
- Improved effectiveness of in-situ technologies and improved confidence in natural attenuation (e.g. further development of chemical sensors and biosensors to characterise sites and to evaluate results of remedial actions);
- Demonstration of source control and pathway interruption as risk management tools vs. source removal;
- Communication / education of people, regulators and all kind of stakeholders and decision makers to tune the perceived risk with the assessed risk.

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[81] CLARINET / NICOLE / ETCA / SENSPOL (2000): "Management of Contaminated Land for the Protection of Water Resources" Joint Statement. September 2000. Available from *www.clarinet.at* and *www.nicole.org*

7.2 Integrated risk assessment[82]

Obviously, the implementation of a risk based philosophy for contaminated land management relies on the quality of procedures for *risk assessment*. In general terms, risk assessment is already a very useful tool in contaminated land management as long as the users of the methods are aware of its limitations. Its strength is that it helps to keep decision making as objective and transparent as possible.

However, the Concerted Action CARACAS revealed that the daily practice of contaminated land risk assessment is largely underpinned by scientific research done for other purposes (e.g. for other compartments such as air or water). Whether current assessment procedures can address the question of *risk* in a rigorous, quantitative way may be questioned. Further development and integration of the underlying scientific building blocks such as soil and water sampling, chemical analysis, exposure modelling and toxicology, which are essential for risk assessment of contaminated soil and groundwater, will increase the quality of current risk assessment procedures.

In a fully integrated approach, choices of toxicological endpoints must have consequences for the design of sampling schemes and exposure models, and vice versa. Uncertainties at each stage in the assessment should be recognised and may lead to the use of probabilistic or other techniques for dealing with uncertainty. Decision-support systems may provide guidance for risk managers to help balance reduction of uncertainties against the costs of additional investigation.

In the context of contaminated land in Europe, risk assessment procedures have been mainly used to set priorities for actions. This means that *risk* is not yet treated as an absolute quantitative measure describing the environmental and human health impact of soil and groundwater contamination, but as an indicator that is used for comparative purposes only. A better term for risk-based priority setting may be *comparative risk analysis. Risk assessment* as such is the scientific process addressing the informal questions *"How risky is it?"* or *"What is the chance of a bad outcome?"*

For an RBLM approach, further research in **quantitative** risk assessment methodologies would support the political decision makers in addressing the informal question "*What risk level is acceptable*", keeping in mind the long term perspective of sustainable development. This will enable decisions on appropriate soil qualities for certain uses and functions and the integration of different approaches such as spatial planning, environmental protection, and economic aspects.

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[82] Research needs for contaminated land risk assessment has been extensively covered in the Concerted Action CARACAS. The interested reader is referred to Chapter 9 of FERGUSON *et al* (1998)

7.3 Exploitation of research results

Besides the initiation of new research, there is a substantial deficit in utilisation of already available research results and in the application of innovative solutions. Existing knowledge is not sufficiently considered and used in practice.

Many analyses have shown that existing scientific knowledge, even when put in a policy and practice orientated context, fails to reach the target groups all by itself. Active knowledge transfer is needed between science, policy and practice in order to

- transfer innovative ideas and technologies into practical applications;
- shorten the time in which real-world problems are addressed by the scientific community;
- gather consensus from different stakeholders on solutions which are technically and financially viable and which take country and regional specific circumstances into account.

In addition, the demonstration of innovative, eco-efficient and cost-effective technologies and methodologies will encourage acceptability and increased use by various decision makers. The implementation of European demonstration programmes and case studies would promote the transfer of research results into practical applications.

Transdisciplinary co-operation between various stakeholder groups is essential to improve the integration of RTD demands (from problem managers) and RTD supplies (by researchers, service providers, RTD programmes). The following section highlights urgently needed measures towards a European research area for contaminated land management.

7.4 Coordination of RTD programmes at a European level

RTD programmes provide an excellent instrument to facilitate the effective implementation of sustainable policies with all stakeholders involved. Although the EU provides a legal basis to initiate suitable measures for international co-operation in research and technological development, the principal reference framework for research activities in Europe is national. Co-operation between research programmes in Europe would accelerate the development of an appropriate knowledge portfolio, needed to implement sustainable land and water management policies.

The Concerted Action CLARINET[83] established a specific Working Group on "Co-ordination of RTD on an European level", where RTD programme managers from 11 European countries and the EU DG Research participated. This Working Group conducted a survey of national and EU research programmes related to sustainable

[83] see *http://www.clarinet.at*

land and groundwater management issues. Some of the major findings of this survey are[84]:

- There is no co-ordination between national RTD programmes in Europe at this stage. Consequently, all countries go through similar learning curves, resulting in a considerable overlap of research projects and targets.
- Altogether, there is about 30 million Euro / year available for contaminated land and groundwater research all over Europe. The total costs for clean-up operations in Europe are estimated to be at least about 90 billion Euro[85]. This means that the annual expenditure in research for sustainable land management is less than 0.5% of the total cost of the problem, which is considerably less than for other areas of environmental management.
- Eligibility for almost all national RTD programmes is restricted to their own national research community and activities. This means that cross-fertilisation and knowledge exchange among European countries from focused partnership projects is not available.
- The dissemination of project findings through national RTD programmes is very modest. Opportunities provided by the Internet are not well used.

The CLARINET Working Group recommends steps towards establishing a co-ordinated European research policy on contaminated land and water management. Some major recommendations to improve the current situation are:

- A European platform of research programme managers. This would enable exchange of information on national research priorities, funding mechanisms and knowledge dissemination. The CLARINET Working Group could be regarded as a first step in this direction.
- 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.
- A joint approach to the needs and means of financing large research projects in Europe. 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.

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[84] CLARINET WORKING GROUP REPORT (2002): *An Analysis of National and EU Research Programmes Related to Sustainable Land and Groundwater Management*

[85] EEA (2000): *Management of Contaminated Sites in Western Europe.* Topic report No.13 / 1999

- Stimulation of trans-disciplinary research involving all relevant stakeholders in the projects.
- Improved dissemination of knowledge in national programmes. The focus should be shifted from pure knowledge supply to "information on demand".

The Working Group's overall conclusion is that enhanced co-ordination between countries' national research approaches will considerably increase the effectiveness and impacts of the resources invested in RTD. This will accelerate the provision of focused scientific knowledge, which is urgently needed to meet the demands for sustainable solutions in Europe[86]. The following section highlights initial measures.

7.5 EU Framework Programmes

Within the 5th RTD Framework Programme (1998-2002), new steps have been taken by the European Commission to address real-world problems with integrated larger scale projects and to stimulate the involvement of stakeholders and endusers in these projects. Activities with greatest relevance to contaminated land management have been conducted within the Key Actions *Sustainable management and quality of water* (Abatement of water pollution from contaminated land, landfills and sediments) and *City of tomorrow* (Rehabilitation and reuse of brownfield sites)[87].

Concerted Actions have been launched to support the implementation of the Framework Programmes. These Concerted Actions bring together the combined knowledge of various stakeholders, such as academics, government experts, consultants, industrial land owners and technology developers. CARACAS[88], NICOLE[89] and CLARINET[90] are such Concerted Action with a thematic focus on contaminated land management[91].

An important role of these Concerted Actions is to support the co-ordination of on-going research activities on a European scale, to identify the state of existing knowledge and to recommend priority research needs to ensure a focused orientation of the RTD Programme. For example, CARACAS and NICOLE identified various areas where significant improvements in the science base would greatly reduce the cost and increase the certainty of fitness for use assessments[92]. These

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86 Commission of the European Communities (2000)

87 BÜSING (2001)

88 CARACAS - Concerted Action on Risk Assessment for Contaminated Sites in Europe; see www.caracas.at

89 NICOLE - Network on Industrially Contaminated Land in Europe; see www.nicole.org

90 CLARINET - Contaminated Land Rehabilitation Network in Europe; see www.clarinet.at

91 CORTESI *et al* (2001)

92 CARACAS / NICOLE (1997)

recommendations on priority RTD needs assisted in the formulation of RTD Work Programmes, both on a European and a national basis.

CLARINET, the successor network of CARACAS, focused on the wider area of risk management, both at a general level of discussion of RBLM and within the individual themes of its working groups[93]. Beside many other outcomes, CLARINET stimulated scientific collaboration between various European countries on high-priority research themes (e.g. BARGE – Bioavailability Research Group in Europe, ECORISK - ecological risk assessment, comparative study on *"Human exposure models")*[94].

New networks of experts such as CABERNET[95] will continue to exchange information and stimulate coordinated research. However, a better research infrastructure in Europe with a focus on demand driven research activities and improved communication and collaboration between scientists from the various institutes in Europe has still to be established.

In the discussion of the upcoming **6th RTD Framework Programme (2002-2006)**, the European Union takes these needs into account. In January 2000, the Commission adopted a Communication proposing the creation of a *European Research Area(ERA)*[96]. This project offers a new horizon for scientific and technological activity and for research policy in Europe. It essentially aims at creating conditions making it possible to increase the impact of European research efforts by strengthening the coherence of research activities and policies conducted in Europe.

New instruments[97] driven by the concepts of the European Research Area will support the implementation of the future Framework Programme. These "new" means, notably the **integrated projects**[98] and the **networks of excellence**[99], are characterised by their capacity to mobilise the critical mass of expertise needed to achieve the ambitious objectives[100].

In order to strengthen the foundations of the European Research Area with the 6th Framework Programme (2002-2006), the Commission recently proposed efforts to

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93 The recommendations derived by the CLARINET network together with other contaminated land related information are available on the CLARINET website *http://www.clarinet.at*.

94 see Chapter 5 "Improved Problem Definition – Determining the Risk" and Annex II

95 Concerted Action on Brownfields and Economic Regeneration under the key action "Cities of Tomorrow" of the 5th Framework Programme.

96 Commission of the European Communities (2000)

97 European Commission (2002)

98 DG Research, Unit B.2 (2002)

99 DG Reseach, Unit B.2 (2002)

100 The interested reader is referred to the CORDIS website *http://www.cordis.lu/rtd2002/home* and the DG Research website *http://europa.eu.int/comm/research*

encourage co-ordination activities, using a bottom-up approach and including the field of **land and soil management**[101]. The CLARINET recommendations[102] may serve as a starting point to move towards a European Research Area in this field.

7.6 The future

The convergence of underlying scientific principles for risk based land management in the European Member States needs to be promoted. This will minimise the current differences in dealing with land contamination from one country to another and, consequently, will reduce the resulting cost differentials which are currently affecting the common European Market. It will also minimise existing differences in public health and levels of environmental protection and / or the perception of these.

Co-operation between research programmes in Europe is needed to move towards a European Research Area (ERA) on contaminated land and water management as targeted by the 6th Framework Programme. A European platform of research programme managers (as initiated by CLARINET Working Group 4 „Analysis of National and EU RTD Programmes Related to sustainable Land and Ground-Water Management“) needs to be established and enlarged. This should include networking of existing centres of excellence and competence in Europe and stimulation of trans-national RTD projects.

The Risk Based Land Management concept (RBLM) offers an overall framework for the implementation of integrated research initiatives. Existing knowledge and techniques in environmental management have to be further developed to increase the range of sustainable solutions. To achieve this, science, technology and environmental management have to work in concert. The establishment of EU Concerted Actions (networks of various stakeholders) is a first step into this direction and should be established on a longer-term basis.

Already existing knowledge needs to be utilised in practice The implementation of European demonstration programmes and case studies would promote the transfer of research results into practical applications. Achieved results need to be transferred efficiently to all practitioners and local decision makers in contaminated land management.

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[101] Commission of the European Communities (2002)

[102] CLARINET WORKING GROUP REPORT (2002): *An Analysis of National and EU Research Programmes Related to Sustainable Land and Groundwater Management.*

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CHAPTER 8 SUMMARY AND RECOMMENDATIONS

"The time has come.
The time of surveillance is past.
The time of waiting for paradise is past.
The time of fruitless talking is past.
The time of action has come."

Hundertwasser

Contaminated land is a problem common to all European countries. It can present risks to human health and to the environment, affecting the quality and use of resources such as soil and water. It can also inhibit the optimum reuse of land, and presents a significant economic and social burden.

CLARINET has covered a range of issues related to contaminated land, ranging from exploring the issues around key policy themes to evaluation of specific scientific aspects and identifying technologies and tools. CLARINET has provided the opportunity to exchange information and ideas, to facilitate new convergent thinking and accessible information, to generate new solutions and to stimulate and promote new research and other initiatives of joint European interest.

CLARINET has focussed its work on priority areas identified by the members, and has not attempted to cover every aspect of contaminated land. It's activities complement and build on activities of other related networks and initiatives on land contamination.

8.1 Risk based land management (RBLM)

To assist in the convergence of thinking and the development of solutions for the problems presented by contaminated land, CLARINET proposes the concept of risk based land management (RBLM)[103]. This aims to integrate the decisions on **timeframe** and on **choice of solution** by considering three components:

- **Fitness for use;**
- **Protection of the environment;**
- **Long term care.**

A structured assessment of these components assists in the analysis of issues underlying decision-making for contaminated land. CLARINET has identified the following key issues:

[103] see Chapter 2 "The Concept of Risk based Land Management"

- 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.

The RBLM concept will assist policy makers and regulators, as well as other stakeholders, in making balanced and informed decisions to achieve sustainable management of land.

8.2 Integrating soil and water management

CLARINET views soil and water as related components of land and resource management. The perspective for both needs to be long term and integrated. CLARINET has explored the issues relating both to the *protection of water resources* and to the *reuse of brownfields*. For both these areas CLARINET has looked at the nature of the problem and the issues at a European level.

CLARINET's key recommendations in relation to the protection of water resources[104] **are:**

- An integrated approach to soil and water management is needed;
- The cost of dealing with pollution of groundwater must be recognised and risk based management approaches must be developed to achieve longer term quality objectives;
- Prevention of future pollution is essential to protect future generations from further burdens;
- Practical approaches and solutions are needed at a European level for effective implementation of the Water Framework Directive.

In relation to redevelopment of brownfields[105]**, CLARINET has similar recommendations:**

- The creation of new brownfield sites must be avoided;
- Spatial planning policies and environmental policies must be integrated to make effective and safe use of land;

[104] see Chapter 3 "RBLM and the Protection of Water Resources" and CLARINET Working Group Report "Contaminated Land and its Impact on Water Resources – Analysis of Questionnaires"

[105] see Chapter 4 "Brownfields – Wider Issues to Contaminated Land" and CLARINET Working Group Report "Brownfields and Redevelopment of Urban Areas"

- More creative solutions should be explored for the economic and social problems presented by brownfields to drive clean up;
- Integrated practical guidance is needed by the range of stakeholders and disciplines involved in brownfield redevelopment.

8.3 Improving problem definition and finding better solutions

CLARINET has explored issues and stimulated new projects to improve knowledge about risk assessment. At a European level, there is still a need for greater awareness and understanding, tools for implementation and skills to assist in risk based decision-making.

CLARINET has the following recommendations for the future of risk assessment[106]:

- Risk assessment provides a structured and transparent approach to decision making which manages uncertainties efficiently and effectively;
- Research must be focussed onto specific needs for improving methods and techniques;
- Dialogue at a European level is needed to stimulate joint evolution of appropriate risk assessment approaches;
- Education and training must be provided at both academic and practitioner level.

The final choice of the remediation approach will be made at the practical level of day-to-day decision-making. CLARINET has identified gaps and weaknesses in current practice, as well as barriers to new solutions and issues relating to the acceptability to different stakeholders.

To assist in finding better solutions, CLARINET recommends[107]:

- Sustainable development and risk management have to be considered in a mutual and holistic way. The use of the RBLM concept will enable a wider perspective in identifying sustainable solutions by balancing the three main components - fitness for use, protection of the environment, and long-term care.
- The wider environmental, economic or social consequences of the remediation work have to be taken into account in the decision making process. Decision support tools could provide a mechanism to evaluate the balance of longer-term aspects against short-term issues for different remediation approaches.
- Research must be focussed onto robust, reproducible and accessible solutions for sustainable contaminated land management. These solutions need to be

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[106] see Chapter 5 "Improved Problem Definition – Determining the Risk" and FERGUSON *et al* (1998)

[107] see Chapter 6 "*Finding Better Solutions*", Clarinet Reports *„Review of Decision Support Tools and their use in Europe"* and *„Remediation of Contaminated Land. Technology Implementation in Europe - State-of-the-Art"*

transferred efficiently to all practitioners in contaminated land management, and be understandable to a wide range of stakeholders.

- A technology certification system on a European basis could increase the confidence into the reliability of innovative environmental technologies and would support the practical implementation of enhanced solutions.

8.4 Towards a European Research Area

CLARINET has explored the research needs to improve the scientific basis for RBLM and to achieve coherent solutions. Specific areas of research have been identified and recommendations made for integration of research and exploitation of research results. One of the areas CLARINET considered in detail was the coordination of RTD programmes at a European level, and the outputs and future directions of the EU Framework Programmes in relation to contaminated land[108].

For the future, CLARINET identified challenges:

- The need to converge scientific principles for risk based land management in the European Member States to minimise current differences in dealing with land contamination from one country to another;
- Co-operation between research programmes in Europe to establish a European Research Area (ERA) on contaminated land and water management;
- The implementation of European demonstration programmes and case studies to promote the transfer of research results into practical applications;
- Encouraging researchers in other fields to contribute to solving the problems of contaminated land.

8.5 The way forward

To put the RBLM concept into practice, action therefore needs to take place on three main fronts:

(1) 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;

(2) in improving practice by the transfer of knowledge and information to a range of groups; and

(3) in integration of policy approaches.

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[108] see Chapter 7 "Towards a European Research Area" and Clarinet Report "*An Analysis of National and EU Research Programmes Related to Sustainable Land and Groundwater Management*"

8.5.1 Research and technical development

As a network, CLARINET integrates the perspectives of policy makers and scientists, with input from practitioners and the problem holders. This has benefited the development of balanced outputs, together with joint RTD projects and other work, which are relevant to real world needs. It has also helped to identify areas where national RTD programmes have common interests and shown that they can work together to support projects of European relevance, such as BARGE[109].

An overall requirement is that research into fundamental science is linked to real world problems, and that international exchange is used to avoid unnecessary duplication, provide a wider basis for scientific peer review, and provide a common database.

CLARINET has made recommendations on priority needs for scientific and research solutions for risk based contaminated land management. New research and tools are still needed in priority areas where knowledge is still only partial, and where new problems are emerging. All of the topics studied within the CLARINET project have identified gaps in knowledge inhibiting either the development or the full effective use of current solutions.

The overall aim should be to focus the research on solutions to questions asked within the RBLM framework, and provide a coordinated research activity across Europe which involves a range of stakeholders, including practitioners.

8.5.2 Practice

At a practical level, CLARINET had to conclude that knowledge and understanding of a risk-based approach to contaminated land has not transferred to general practice. Scientists, industry, and other practitioners need to encourage the transfer of the current knowledge base, and the RBLM approach, into current practice.

A relevant factor is the divergence of competent authorities who have responsibility for different aspects of land contamination, ranging from local to national level, and from planning control officials to public health assessors.

Key recommendations from CLARINET are therefore:

- To disseminate information about the underlying principles and tools in risk assessment and risk management to a wider range of decision makers and practitioners, in particular in SMEs.
- To train practitioners, particularly regulators at a local level, in methods for risk assessment and risk management.

[109] BioAvailability Research Group in Europe: *www.schelwald.nl/pages/barge*

Underlying this need for training at the applied level is a more fundamental need for multi disciplinary education, professional development and exchange of experience and perspectives.

One of the main areas where practice will benefit from multidisciplinary exchange is in the area of *brownfield redevelopment*. The focus here should be on stakeholders working together to turn a threat into an asset.

Finally, in almost all aspects of CLARINET's work there was a recognition that:

- the citizen needs to be involved more in decision making, and that this would need development of procedures for *risk communication*;
- technical approaches need more harmonisation across Europe and more integration between different aspects of the overall process of risk assessment and risk management.

8.5.3 Policy

Finally, at an EU and national level, policies, programmes and strategies related to protection of the environment and health, spatial planning and economic development need to have cross linkages and integrated objectives. This will help to achieve sustainable solutions for contaminated land. This is discussed further in the final chapter of this report[110].

8.6 Future challenges

There are new pressures on the environment, such as the pressure of urban growth, declining soil resources and the need to conserve and enhance the quality of ground and surface waters. There is increasing pressure at a regional and national level to ensure that economic growth is sustainable and achieves an improved quality of life. There are also changes in the way in which communities might expect to participate in decision-making. These in turn will put pressure on the way in which contaminated land is managed, both at an individual site level and at a European level.

CLARINET sees the following key challenges for scientists, policy makers and industry in the future:

- achieving a common understanding of issues to open up discussion of the time, land use and resource needs for different solutions;
- ensuring that solutions are transparent and include long term management;
- finding a way jointly to establish sufficient long term funding from both public and private sectors to ensure that serious problems are tackled and that there is a continuing improvement in the condition of land across Europe.

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[110] see Chapter 9 "RBLM with regard to Soil & Water Protection"

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.

CHAPTER 9 RISK BASED LAND MANAGEMENT WITH REGARD TO SOIL & WATER PROTECTION

… we complain today about the neglect of past generations in preserving the land quality, tomorrow we should not create the same problems again for future generations …

9.1 Introduction

Risk based land management (RBLM) provides a framework to address problems of *contaminated land*. Contaminated land usually refers to land that has been contaminated by persistent toxic substances due to past industrial uses. This raises the question whether risk based land management could also be a useful concept for policies concerning all situations where soil functions are seriously affected, and even whether it could be used as a concept in soil protection. If contaminated land has negative consequences and needs to be managed, it seems only logical that all land needs to be managed to prevent contamination.

Although it is now generally recognised that soils are exposed to many pressures, policy development - especially in prevention of soil problems - lags behind other areas of environmental policy like air and water. A comprehensive policy for soils and integration of soil policy in overall environmental policy is needed to avoid the pitfalls of fragmentary ad hoc approaches and reactive management of incidents.

Experiences with restoration of contaminated land have shown that it is very difficult and costly to repair a damaged soil. Most damage, whether due to chemical pollution or other degradations like acidification, desertification, erosion and salinisation, tends to be irreversible. Because soil is such a slow reacting compartment, interaction between different impacts on soil is very likely.

These factors, together with the problem that soil pressures and responses are quite diverse, are not easy to bring under a common strategic policy umbrella. This implies the need for a flexible but integrated view on *soil resource management*.

9.2 An integrated view of soil resource management

The Council of Europe put the need for soil protection in an international perspective in 1972. They laid down the general principles of soil protection in the European Soil Charter (Council of Europe, 1972). The following principles underlay the proposals for international action:

- Recognition that soil is a common heritage and non-renewable resource;
- Integration of soil protection into other environmental policies;
- Rational use of soil and careful management of soil;
- Respect for multi-functionality through harmonisation of surface land use;

- The reversibility rule (impact on soil quality by man should be reversible).

It is important to note here that the principles for soil protection are based on “careful soil management” and reversibility of human impact, and not on a prohibition on use of soil. This underlines the difference between soil protection and nature conservation. A second important point is that these principles anticipate future land use, and are in agreement with modern environmental policy objectives like "sustainable development" (WCED, 1987)[111].

Compared to the activities of the Council of Europe, the objectives of the European Union (EU) environmental policy did not address soil specifically, until the publication of the 6th environment action programme in 2001. There are, however, a number of EU directives on waste management and (ground) water quality with beneficial side effects for soil quality.

The 6th environment action programme[112] states that a thematic strategy for soil protection is needed, in view of the complex nature of the pressures weighing on soils. It is also stressed that a soil policy must be based on a sound basis of data and assessment. Further development of the EU thematic strategy for soil is centred on the draft Soil Protection Communication[113] published by the commission (DG Environment) and the discussions in the European Soil Forum, a forum of policy developers and scientific advisors of EU member states and accession countries. By providing policy relevant information on soil-related issues in the form of analysing the states and trends in the soil environment and assessing the causes of changes the European Environment Agency supports the European Commission in their decision making[114].

It is recognised that many EU policies have consequences for soil quality. Effects of these policies may be beneficial in view of soil protection but there may also be adverse effects. Possible adverse effects of these policies should be anticipated and mitigated. The Soil Protection Communication also recognises that soil protection cannot remain a by-product of other regulations. A specific soil protection policy framework is needed, not only at the level of individual member states but also on the EU level.

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[111] World Commission on Environment and Development (1987): "Our common future". Oxford University Press, Oxford.

[112] European Commission (2001): EC Communication on the sixth environment action programme of the European Community *'Environment 2010: Our future, Our choice'*. Brussels, 24.1.2001, COM (2001) 31 final

[113] European Commission (2002): EC Communication *"Towards a Thematic Strategy for Soil Protection"*. Brussels, 16.4.2002, COM (2002) 179 final.

[114] European Environment Agency (2000): *Management of contaminated sites in Western Europe*, Topic report No.13/1999

9.3 Risk based land management (RBLM)

CLARINET[115] considers that the RBLM concept should influence the further development of a wider soil protection policy framework. RBLM focuses on site-specific management choices. These must consider adverse effects of contamination on land uses and functions, impacts on surrounding land and water and long-term management considerations. Within the RBLM concept, solutions for contaminated land are flexible and not based on fixed national or supranational numerical standards. It is of course obvious that this freedom for site specific decision making has to be surrounded by some hard boundaries, which are set for instance by the acceptability of human health risks. Furthermore RBLM decision-making is intended to be transparent so that it can be democratically applied.

Another important aspect of RBLM is the spatial dimension implied by the word “land”. This opens the possibility for a hierarchical management system based on different spatial units of land. For instance a farmer or industrial landowner can be regarded as the manager of his land within a legal framework or a mandate given by a higher level authority like a municipality or a province. Because the soil environment has its own natural structure and intrinsic properties it would be beneficial to take also natural boundaries between different soil situations into account in the design of hierarchical soil management systems. This becomes more obvious when the close relation between soil and water is considered.

It has to be recognized that RBLM, as developed by CLARINET, is primarily focussed on risk management of contaminated land. However it is also a framework both for addressing uncertainties, and for integration of wider environmental, spatial planning and water management issues. These will be relevant for the prevention of future land degradation.

Preventing land and water resources from degradation requires comprehensive knowledge about the significance of damage and about the connection between the pressures on soil (or land) and the resulting effects. This is a complex issue and the current level of scientific knowledge is poor.

The RBLM approach offers a practical way forward to identify and assess the measurable effects from existing land degradation. It can also be used to evaluate the overall effect of counter measures or to compare the effects of different counter measures. Experience from development of strategies for managing contaminated land may greatly contribute to wider management strategies to prevent soil problems.

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[115] CLARINET – Contaminated Land Rehabilitation Network in Europe: *http://www.clarinet.at*

9.4 Integrating soil and water

Environmental policies for water have moved to a management approach at a water system level which addresses the ecological quality of surface water and groundwater in river basins. The Water Framework Directive (WFD)[116] will lead to regional water quality management and control of sources of pollution of groundwater and surface water.

In the implementation of the WFD the large European river basins are likely to be divided in smaller regional management units. The CLARINET working group on protection and rehabilitation of water resources addressed management at this level in relation to the RBLM framework.

As groundwater is intrinsically in the land and the land is a sink for many pollutants, contaminated land or soil (whether industrially contaminated or agriculturally contaminated) is an important source of water pollution. On the other hand water pollution can be a significant source of land or soil pollution. This will be obvious in countries where sediments are considered as soils in aquatic ecosystems. But it applies in many other circumstances, ranging from the spread sediments over soil via flooding or by deposition of dredged materials to the transport of contamination by water movement within soils.

The interaction between soil and water is also important in environmental problems that are not caused by polluting substances. Overexploitation of the water cycle leads to soil problems such as desertification and salinisation. The close link between soil and water is well established in terms of soil science - soils are formed in close interaction with the water cycle and plant and animal life.

So from an environmental point of view soil and water interact too much to be managed separately. Successful implementation of the WFD has to involve land management.

9.5 Proactive spatial planning of sustainable use of land and water

The above stressed the importance of linking soil and water protection. Because of the spatial component in both, and the need for a proactive planning for the future uses of soil and water resources, there is also a strong relation with spatial planning policy. Sound management of soil and water resources calls for harmonisation of spatial planning with the environment, so that land uses can be optimised with respect to soil quality and hydrogeological context. This is in fact an extension of RBLM, which addresses opportunities for safe use of resources as the positive solution to “risk”, by looking at optimal combinations of land and land use to achieve sustainability.

[116] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing *a framework for Community action in the field of water policy*.

To put the perspectives of sustainable soil and water management as described above into practice, it is important to be aware of the limitations in knowledge about causes and effects of current and future human impacts on land and water. Over and above the need to satisfy the precautionary principle, it is clear that we must take great care to ensure that we both protect and restore land to ensure that future generations have a better legacy than the one we have received from the past.

GLOSSARY - Terms used in CLARINET Work

Different people use a number of different acronyms, terms and concepts in discussions about contaminated sites. Some of these terms are specialist in the way in which they relate to land contamination; others are also used in other contexts - where their meaning may be slightly different.

This "glossary" provides a guide to the meaning of some of the key terms in the way in which they have been generally used in the CLARINET work, and in particular in this overview report.

Term	**Explanation**
Aftercare	A specific series of technical or management actions necessary for managing a remediated site in the long term.
BARGE	BioAvailability Research Group in Europe: *www.schelwald.nl/pages/barge*
BATNEEC	*The best available technology not entailing excessive costs.*
Brownfields	In general terms, land used in the past in a way which has left it not fully suitable for new uses. The specific definition used for the CLARINET study is: "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
CABERNET	Concerted Action on Brownfields and Economic Regeneration Network: *www.cabernet.org.uk*
CARACAS	Concerted Action on Risk Assessment for Contaminated Sites in Europe: *http://www.caracas.at*
CLARINET	Contaminated Land Rehabilitation Network in Europe: *http://www.clarinet.at*
Comparative risk analysis	Risk-based priority setting
Contaminated land	Usually, a general term to describe sites or wider areas of land where elevated concentrations of chemicals or other substances may be found. *(Note: Some countries have a specific legal definition)*

Term	**Explanation**
Contaminated site	A particular area of land, usually related to a specific area of ownership or activity, where elevated concentrations of chemicals or other substances may be found.
Contamination	Elevated concentrations of chemicals or other substances.
Damage	If an adverse effect has occurred, the consequences are often described as *damage*. Adverse environmental effects are generally considered as the result of a process where some potential hazard (a toxic substance or other agent) affects a target to be protected (people, animals and plants, ecosystem processes, water resources or buildings).
DST	Decision support techniques or tools
Development control	Part of spatial planning, usually relating to the regulatory or permitting regime for new uses of particular land, or sites.
Diffuse contamination	Large geographical areas with elevated concentrations of chemicals or other substances.
Drivers	Initiating factors for any particular project or action.
EEA	European Environment Agency
Ecological	Relating to ecosystems.
Ecosystem	A local biological community and its pattern of interaction with its environment.
Environment	Man’s surroundings, including soil, water, air, buildings and ecosystems.
Environmental	Relating to any component of the environment.
ERA	European Research Area
ETCs	European Topic Centres: *are institutions/organisations contracted by the EEA to execute tasks identified in the Multiannual Work Programme.*
Fitness for purpose	An assessment that the physical condition of the site can support a particular use.
Fitness for use	An assessment that quality of the land is “acceptable” for its use or reuse.
Framework Programme	The European Community’s Framework Programme set out the priorities for the European Union's research, technological development and demonstration (RTD) activities

Term	**Explanation**
Groundwater	All water which is below the surface of the ground in the saturation zone and in direct contact with the ground of the soil.
Hazard	The presence of contamination which represents a risk.
Hot spots	Specific areas with high concentrations of contaminants.
Land	A geographical area, including the soil, buildings and groundwater directly beneath the surface
Land use planning	Alternative term to *spatial planning*, used for example in the UK
Lay stakeholders	Those who do not have a role related to the specialist contaminated land professional or administrative activities in the project
Legacy contamination	Contamination resulting from past practices
LCA	Life cycle analysis
LIBERATION	European research project on the sustainable management of contaminated land by linking bioavailability, ecological risk and ground water pollution of organic pollutants; see *http://www.liberation.dk/*
Long term care	The wider policy, regulatory and management actions needed to control and monitor land over time.
MCA	*Multi-Criteria Utility Analysis*: A structured system for ranking alternatives and making selections and decisions.
Monitored natural attenuation (MNA)	Refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site remediation approach).
NICOLE	Network on Industrially Contaminated Land in Europe: *http://www.nicole.org*
Pathway	The linking of the contamination and the effects at receptors of concern
Point of compliance	Location at which measurements should be taken to compare results with quality standards or other criteria.
Point sources	Former industrial or waste disposal sites.
Pollution	The presence of elevated concentrations of chemicals or other substances which has degraded the quality of the medium.

Term	**Explanation**
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.
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.
RBLM	Risk Based Land Management
Receptor	What is affected by the contamination, for example humans, animals, plants, ecosystems etc.
Risk	The combination of the probability and the effects of contamination.
Risk assessment	Identification and evaluation of risks
Risk Based Land Management	Framework for decision making processes for contaminated land in general – not necessarily a particular site
Risk Based Site Management	Decisions related to resource allocation, urgency of response, target cleanup levels, and remedial measures on a particular property.
Risk communication	Effective communication of information and opinion on risks associated with real or perceived hazards.
Risk management	Overall process of identifying and dealing with or controlling risks.
RTD	Research and technical development.
Site	A particular area of land, usually related to a specific area of ownership or activity.
SME	Small and medium-sized enterprises.
Soil	General term to mean the material on the surface of the underlying geological materials.
Source	The contamination in the soil or water.
source-pathway-receptor paradigm	One of the fundamental approaches to assessment of contaminated land and development of solutions. In this context, the *source* is the contamination in the soil or water; and the *pathway* is what links the contamination to the actual or possible effects at the *receptors* of concern.
Spatial planning	The process whereby the use of land is controlled at policy or regulatory level.

Term	**Explanation**
Stakeholders	Those who have a direct or indirect interest in the outcome of decisions.
Standard	A predetermined measure of quality. It may be applied at any stage in the process of assessing quality. It may be quantitative (for example numeric limits on concentrations of substances in a particular medium), or it may be qualitative (for example using more subjective terms such as “safe to live on”).
Sustainable development	Ensuring that the needs of future generations are not compromised when meeting the needs of present generations in terms of society, environment and economy.
Suitable for use	Policy approach in the UK which combines the requirement for fitness for use with protection of the environment, based on the current use of a site.

Sustainable Management of Contaminated Land: An Overview

Further CLARINET publications in this series:

Contaminated Land and its Impact on Water Resources

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An Analysis of National and EU RTD Programmes related to sustainable Land and Groundwater Management

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