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Assessing Risks from Contaminated Sites: Policy and Practice in 16 European Countries

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Abstract

A concerted action initiative on risk assessment for contaminated sites (CARACAS, 1996 – 1998) was funded by the European Commission under the Environment and Climate Programme and coordinated by the German Umweltbundesamt. A major outcome of CARACAS has been the publication of two books. The first (Ferguson et al. 1998) covers the scientific basis for risk assessment. The second (Ferguson & Kasamas 1999) provides authoritative and detailed reviews on policy and practice in the 16 European countries contributing to the CARACAS programme: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom. This paper summarises policy and practice in those 16 countries.

INTRODUCTION

Twenty or so years ago land contamination was usually perceived in terms of relatively rare incidents, with poorly known but possibly catastrophic consequences for human health and the environment. Several incidents attracted major media attention, e.g. Love Canal, New York State; Times Beach, Missouri; Lekkerkerk, The Netherlands. As a result politicians responded by seeking maximum risk control: pollution should be removed or contained completely. The Superfund programme in the USA, which was largely a response to Love Canal and a few other highly-publicised sites, initially focused on 'the worst 100 sites in the nation'. Even today, after almost 20 years and the expenditure of many billions of dollars, the number of US sites cleaned up under the Superfund programme amounts to only a few hundred.

Today land contamination is no longer perceived in terms of a few severe incidents, but rather as a widespread infrastructural problem of varying intensity and significance. It is now widely recognised that drastic risk control, for example cleaning up all sites to background concentrations or to levels suitable for the most sensitive land use, is neither technically nor economically feasible. To give an example, in 1981 about 350 sites in the Netherlands were thought to be contaminated and possibly in need of remedial action. By 1995 the number had grown to 300 000 sites with an estimated clean-up cost of 13 billion ECU. Similar circumstances exist in most other industrialised countries. Consequently, although the need for policies to protect soil and groundwater is recognised, strategies for managing contaminated land have moved towards *fitness for use*.

Land contamination remains high on the agenda of environmental and regeneration programmes in most European countries. In 1994 a Common Forum for Contaminated Land in the European Union was established by Member States, the Commission of the European Communities (CEC) and the European Environment Agency (EEA). The Common Forum had several key objectives:

1. to facilitate better understanding of each Member State's approach to tackling the problems of land contamination;
2. to identify thematic areas for EU-wide cooperation;
3. to make recommendations on technical and practical issues to the CEC and the EEA;
4. to enhance the dialogue between the various inter-

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national initiatives concerned with land contamination and regeneration.

One outcome of the Common Forum's first meeting (Bonn 1994) was a recommendation to promote an EU-wide project on assessing the risks from contaminated sites. This led to the Concerted Action on Risk Assessment for Contaminated Sites (CARACAS), an initiative funded by the CEC under its Environment and Climate Programme and supported by the participating countries with individual accompanying measures. The project was initiated by the German Environment Ministry and coordinated by the Federal Environment Agency (Umweltbundesamt). The work programme of CARACAS, which started early in 1996, has been carried out by more than 50 scientists and policy specialists from 16 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

In addition, close links were formed between CARACAS and other initiatives including: NICOLE (Network for Industrially Contaminated Land in Europe), an industry-led concerted action programme; RACE (Risk Abatement Centre for Contaminated Sites in Central and Eastern European Countries); the EEA's European Topic Centre on Soil; and the International Standards Organisation Technical Committee TC190 dealing with soil quality.

The work of CARACAS focused on seven topic areas:

- human toxicology;
- ecological risk assessment;
- fate and transport of contaminants;
- site investigation and analysis;
- models;
- screening and guideline values;
- risk assessment methodologies.

A major outcome of CARACAS has been the publication of two books (Ferguson *et al*. 1998; Ferguson and Kasamas 1999). The first covers the scientific basis for risk assessment, largely structured according to the topic areas listed above. The second volume provides authoritative reviews of policy and practice relating to risk assessment of contaminated sites in the 16 contributing countries. This includes details of policy background, legislation, technical approaches used for risk assessment, key technical guidance documents, and contact details for policy and technical specialists in each country.

The purpose of this paper is mainly to provide a short and easily accessible review of policy and practice in the 16 CARACAS countries. Of course, in condensing a 223-page book into a short paper, much has been omitted including details of specific policy and technical guidance documents, and contact details for key personnel. The reader requiring such details, or a more complete account of policy frameworks in particular countries, should consult Ferguson and Kasamas (1999) and the references cited therein.

This paper would not have been possible without the dedication and hard work of those who contributed as chapter authors to Ferguson and Kasamas (1999). They are listed in full in the acknowledgements section. However, in producing this highly condensed version, the responsibility for any factual errors, omissions and misinterpretations is mine alone.

Austria

The Federal Constitution in Austria contains provisions for keeping soil clean, but there is no specific national soil conservation act. Soil conservation is a responsibility of the provincial authorities, although it is focused exclusively on restoring and maintaining agricultural land.

The Act for the Clean-up of Contaminated Sites (*Federal Legal Gazette* no. 299/1989) was primarily meant to be a means of funding clean-up measures, and provides for the Federal Ministry (for Environment, Youth and Family) to coordinate the investigation, assessment and remedial response to contaminated sites at a national level.

There are no general intervention values for evaluating polluted soils. It is preferred to base evaluations on site-specific circumstances, especially local geological conditions and anthropogenic influences on soil quality. However, generic criteria may be used as a starting point for site evaluation and, together with consideration of site conditions, are used in risk assessment and deciding on the need for action.

More than 99% of Austria's drinking water is supplied by groundwater. Hence there is a very strong emphasis on prevention of groundwater pollution. The Austrian Water Act (*Federal Legal Gazette* no. 215/1959, the Act as amended) is also characterised by its use of the precautionary principle. According to Austrian Standard ÖNORM S 2088-1, three criteria form the basis for assessing risks to groundwater: the harmful potential of polluting substances; the geological and hydrogeological conditions at the site; and the potential for contaminant dispersal in groundwater.

The hazardous substances in a waste deposit or polluted soil, and their likely environmental behaviour, are assessed using analytical results from direct sampling. To help evaluate the potential for harm, refer-

ence values are provided for eluate concentration, soil gas concentration and 'total' contaminant concentration. These values were derived following review of the specialist literature, and of standards derived elsewhere. Groundwaters are categorised into those important for water supply (which enjoy special protection) and those that are not exploited. More stringent reference values apply to the former.

Groundwater studies always include an assessment of the geology and hydrogeology of the site and its surroundings with regard to the possible migration of hazardous substances, including identification of relevant pathways and geological barriers. Assessing the dispersal of hazardous substances in groundwater focuses on the degree to which a waste deposit or contaminated site causes, or could cause, changes in groundwater quality. To assist in the interpretation of chemical analysis results, screening values and intervention values are available, although they are not related to groundwater use. By definition exceeding a screening value triggers the need for further investigation. Sites with contaminant levels below the screening values are determined not to pose potential risks. Exceeding an intervention value implies higher potential risks. This usually requires consideration of remedial action. The intervention values are generally derived from drinking water standards. However, reference values are no more than a support tool for the risk assessment of potentially contaminated sites. Any decision has to be made in the light of specific site conditions.

Since late 1997 various experts have been working on Austrian Standard ÖNORM S 2088-2. Within this framework, assessment criteria for soil contamination and its direct effects on humans, plants and animals should be established. The current view is that intervention values will be established only for sensitive land uses (children's playgrounds, residential areas). For all other types of use (agriculture, industry) screening values will be established.

Belgium

In Belgium responsibility for environmental policy rests with the three regions: Flanders, the Walloon Region and the Brussels-Capital Region. This also applies to contaminated land policy. At the time of writing only Flanders has adopted a full legislative framework for contaminated sites, the Soil Remediation Decree ratified by the Flemish Government in February 1995. The responsible authority is OVAM (Public Waste Agency of Flanders). It is important to note that, under the Decree, soil includes both the solid phase and groundwater.

The Flemish Decree contains a number of key ideas which address new ways of handling land contamination:

- a register of polluted sites and the opportunity to request a soil certificate, including an extract from the register;
- a distinction between historic and new soil pollution;
- a distinction between obligation and liability for remediation.

Following from this Decree there are strict procedures for soil investigation and remediation, starting with a preliminary soil investigation and followed when appropriate by a full (quantitative) soil investigation, a soil remediation plan and the remedial works themselves. It is obligatory for a soil investigation to be carried out when property is transferred, and on the closure of certain installations which have the potential to cause soil pollution.

An exploratory investigation includes a limited investigation into the past history of a site, as well as some restricted sampling. Where these preliminary investigations indicate the presence of pollutants, further assessment is based on comparing measured concentrations with soil clean-up values. A full soil study involves investigating pollution in detail, and characterising the risks to human and ecosystem health. Particular aims are to provide a detailed description of the nature, extent, concentration and origin of the contaminating substances; their spatial variability; their potential for migration; and the risk from exposure to humans, plants and animals as well as surface and groundwaters.

'Historic' soil pollution is defined as pollution which occurred before the Soil Remediation Decree came into force on 29 October 1995. 'New' soil pollution originated after the Decree came into force. The Decree requires that clean-up of new pollution should take place whenever soil clean-up values are exceeded. When pollution is historic, the decision to clean up will depend on the estimated risks posed to man and the environment. The appropriate remedial actions are determined by a soil remediation plan. Clean-up operations are supervised by OVAM.

The Flemish register of polluted soils serves as a database for policy decisions and also functions as an instrument for protecting and informing potential buyers of polluted sites. The register of polluted land is open to the public.

Under the Flemish Decree an obligation to clean up falls on the operator or owner of the land *where the pollution entered the soil*. Where *new* pollution is con-

cerned the obligation is automatic. With *historic* pollution, the obligation only arises after a government order to clean up. In other words, the Flemish Decree introduced a non-retroactive strict liability rule, and channelled the liability for new pollution to those that caused it. However, recourse against other responsible parties is possible. With respect to historic pollution, liability is determined by the rules in effect before the decree came into force.

The owner or operator of land where pollution entered the soil is not obliged to carry out a clean-up if he can prove that he did not cause the pollution (by his negligence or otherwise), and that when acquiring the property he was not aware and could not have been aware of the pollution. In addition the owner of a site with historic pollution is not obliged to carry out a clean-up if he proves that the polluted land was acquired prior to 1993, and since then has been used exclusively for non-commercial use even though he may have had prior knowledge of the pollution.

Soil clean-up values are defined as levels of soil pollution above which serious harmful effects for man or the environment might occur, taking into account the characteristics and functions of the soil. An exposure assessment model has been used to derive soil clean-up values for the solid phase. It is based on the formulae used in the Dutch HESP model, with some additions and modifications. These changes relate mainly to chemical-specific parameters and to land use. Six land use scenarios have been defined for four land use classes: agricultural, residential, recreational, and industrial. Each land use class has been characterised by typical exposure pathways and by typical human activity patterns.

For each pollutant, exposure calculations for each scenario were undertaken to estimate a total exposure equal to the Tolerable Daily Intake (TDI) for non-cancer effects, or the dose corresponding to a theoretical excess lifetime cancer risk of 10^{-5}. Values for TDI and unit cancer risk are taken from internationally respected databases (e.g. World Health Organisation, US Environmental Protection Agency). Total exposure comprises exposure from the polluted site together with background exposure from undefined sources. As well as criteria based on human exposure, additional limiting criteria may be used depending on land use type, in particular phytotoxicity and air quality guidelines. For 'nature areas' a separate approach is currently being developed. Soil clean-up values for groundwater are not based directly on risk assessment but represent drinking water quality standards.

Consultants who perform soil investigations under the Decree on Soil Remediation have to be recognised by OVAM. A condition of their recognition is that they must use a groundwater model and a recognised risk assessment model. Since the end of 1997 there is one recognised risk assessment model, called VLIER-humaan (Flemish Instrument for the Evaluation of Human Risks). It comprises the same formulae and parameter values as the model used for deriving the soil clean-up values. Although similar to the Dutch HESP and C-Soil models, it has been specifically adapted for Flemish conditions. Recognition of this one model does not currently mean that other models cannot be used, but use of other models is likely to increase the time taken to evaluate a full soil investigation. In due course other models may also receive recognition by OVAM.

The use of recognised models does not, of course, guarantee the quality of a soil investigation. For this reason a protocol for full soil investigation has been written and is in the final phase of being approved. The protocol does not aim to provide a stringent framework for each step of the soil investigation. It is more a guidance document to ensure a base level of quality while at the same time giving consultants the flexibility to use their own expertise. The protocol covers both site investigation strategies and risk evaluation.

Denmark

In the early 1970s the authorities in Denmark realised that there were potential problems with some contaminated sites, especially landfills containing chemical waste. The uncovering of buried waste in a number of redevelopments during the 1970s led to enactment of the Contaminated Sites Act of 1983. During the 1980s it also became clear that landfills containing household waste, and industrial activities, could pose a risk to man and the environment. As a consequence the Contaminated Sites Act was revised in order to include all types of contaminants.

Groundwater protection and contamination at residential sites are the two contaminated land problems given top priority in Denmark. Water supply in Denmark originates almost entirely (95%) from groundwater sources. The Danish counties have designated areas of special interest for future water supply, and these cover 35% of the country. Designated areas play a key role in the prioritisation of contaminated sites for investigation and remediation.

Danish environmental legislation is based on the 'polluter pays' principle. However, in recent years several lawsuits have shown that strict liability for contaminated sites cannot be applied within Danish civil law. The Supreme Court has ruled against the Ministry of Environment & Energy in a number of cases where it could not be proved that the polluter

was acting in bad faith at the time the pollution occurred.

A ruling from the Supreme Court in 1992 states that the normal time limit for liability in cases of soil contamination is 20 years. As a consequence, a polluter cannot be held liable for contamination that took place more than 20 years ago irrespective of whether the polluter acted in bad faith.

As a supplement to the Act on Contaminated Sites, a special clean-up system for home owners was introduced in late 1993 with the Act on Economic Blight to Family Housing on Contaminated Land (The Loss of Value Act). By paying a minor contribution, the homeowner can initiate a publicly financed clean-up. Under the Loss of Value Act, no distinction is made between contamination which occurred before the mid-1970s and after; instead protection of the innocent landowner is of paramount importance. This implies that if the owner himself has caused the contamination, for example as a result of having run a small business on the premises, he is not entitled to help. The same applies if he knew about the pollution at the time of purchase and therefore obtained the property at a reduced price.

Regional authorities, being the 14 counties and the municipalities of Copenhagen and Frederiksberg, are responsible for registration, investigation and remediation of contaminated sites covered by the Act on Contaminated Sites and the Loss of Value Act. The 275 municipalities are responsible for the majority of sites covered by the Environmental Protection Act. The Danish Environmental Protection Agency provides guidance for the work of the regional and local authorities and supports research and development.

In 1994 the Minister for Environment and Energy set up a Contaminated Land Committee. In 1996 the Committee submitted a proposal for revised contaminated site legislation, and in January 1998 a revised proposal was sent for comment to industry, interest groups, other ministries etc. The proposal was presented to Parliament in February 1999.

The major provisions of the proposal are as follows:

- all contaminated land would be covered as well as all aspects of soil contamination, including management of soil that has been excavated and transported;
- no distinction would be made between contamination that took place before and after the mid 1970s;
- all contamination that occurs before the new legislation comes into force would be subject to the same regulation, i.e. the 'polluter pays' principle would be applied and enforced, with the caveat that it would be so only if it can be proved that the polluter was acting in bad faith at the time the pollution occurred; and
- all contamination that occurs after the new legislation comes into force would be subject to strict liability, i.e. the stringent application of the 'polluter pays' principle.

In 1990 the counties started systematically investigating all sites that were being or had been used for activities that presented a potential contamination risk. If an investigation reveals that a site is contaminated to a level which presents risks to human health or the environment through its current use, or water pollution, the site is considered to be contaminated and is registered as such in the Danish Inventory of Contaminated Sites. Furthermore, the risk assessment also includes an evaluation of whether the site would be considered a risk if it were to be used for a more sensitive use, such as housing. If that is determined to be the case then the site is also to be registered in the Inventory.

Risk assessment procedures

Sites on the Danish Inventory of Contaminated Sites are prioritised according to their need for remediation. Since nearly all drinking water is derived from groundwater, groundwater protection has a very high priority. Standards for groundwater that is or may be used for drinking water are based on drinking water standards. Generally a lower priority is given to surface water.

Usually, risk assessment is based on determining contaminant concentrations and comparing them with the quality criteria for soil, groundwater or air. If the concentration of a specific contaminant is found to exceed the relevant criterion, the site is considered to present a certain risk to humans and/or the environment. This will result either in further field investigation to improve the initial risk estimate, or in remedial action.

In September 1998 a new Guideline on Remediation of Contaminated Sites was issued. It provides a detailed description of the management of contaminated sites including field survey methods, collection of samples, site characterisation, conducting risk assessments and implementation and control of remedial actions. To assist in assessing risks for very sensitive land uses such as housing with gardens and children's playgrounds, topsoil quality criteria for approximately 50 substances have been elaborated based on human toxicity. The decisive receptor is usually taken to be a two-year-old child who is assumed to eat 0.2 g soil/day, or on isolated occasions 10 g of soil.

The new guidance also introduces a new type of guideline value for soil. It is called a 'cut-off value' indicating that if contamination is below that value, remediation is not necessary because exposure can be reduced to an acceptable level by reducing the contact with soil, e.g. not eating home-grown vegetables or replacing bare soil with a lawn. If the cut off value is exceeded at sites used for residential purposes the exposure should be cut off either by remediation or by establishment of a barrier.

For substances giving rise to chronic toxic effects, e.g. Pb and Cd, the average concentration of the samples should meet the relevant soil quality criteria. In the case of substances that could give rise to acute toxic effects, e.g. Ni and As, the average concentration should meet the soil quality criteria but in addition no more than 10% of the samples may exceed the criteria by more than 50%. If this condition is not met the area represented by the samples is considered to pose a significant risk.

With respect to soil contamination in relation to groundwater, the objective is to protect groundwater as a resource irrespective of whether abstraction wells are located in the area or not. The groundwater quality criteria are based on guideline values for drinking water. Hence groundwater, after ordinary water treatment processes, must fulfil the drinking water standards. Groundwater quality criteria have been derived for approximately 50 substances. Some of the general principles are:

- If groundwater quality criteria are exceeded a further stage of investigation may be needed to refine the initial risk assessment. Proceeding to this next stage generally requires more site-specific data.
- Risk assessment includes determining whether site contamination affects or could affect groundwater quality at various distances from the site. The estimated concentration in the aquifer at a remote compliance point is then compared with the groundwater quality criteria.
- The presence of free phase contaminant is considered to present a risk.

Assessing the risks from volatile soil contamination in relation to indoor air is based on contaminant transport by diffusion through pore spaces in the unsaturated zone and transport by convection into buildings through gaps in concrete floors. If the estimated contaminant concentration in indoor air exceeds the air quality criterion, the contamination is considered to present a risk.

Finland

There is no separate legislation in Finland covering soil protection or remediation of contaminated sites. However, contaminated land has been defined as waste, and assessment and remediation of older sites is regulated under the Waste Management Act. The Waste Act of 1 January 1994 regulates pollution after that date. It also makes owners responsible for establishing the contamination status of their property, and transferring this information to buyers.

Measurement-based assessment of risk at Finnish contaminated sites is usually done by comparing observed concentrations with guideline values for soil contaminants. Preliminary guideline values for some 170 compounds were published by the environmental administration as part of a nation-wide contaminated site inventory and clean-up project. These preliminary values were mostly based on earlier (mainly Dutch) values which were underpinned by limited toxicity assessments, often involving very conservative assumptions and safety factors. Some modifications for metals were based on comparisons with Finnish soil quality data. Updated Finnish guideline values have been proposed by the Finnish Environment Institute for substances which are unambiguously identifiable, commonly used or occurring, capable of analysis in soil by standard methods, and tested for toxicity to soil animals. The two-level guideline system includes target and intervention concentrations derived mainly on the basis of ecotoxicity but also including some human health considerations. Values for different land uses have not been presented due to the emphasis on long-term multifunctionality of soil.

The decision procedure for deriving guideline values varies according to substance, but may be described as a tiered multi-criteria, weight-of-evidence approach taking into account the representativeness and reliability of toxicity data (for various taxa) and the type of effect.

Updated Finnish soil quality guidelines are currently being prepared by the Ministry of the Environment, and will be subject to consultation with other branches of the administration and with other interested parties. Guideline values for compartments other than soil have also been proposed or are under preparation. Existing guidelines include those for heavy metals in sludge, for occupational air quality, and for contaminants in potable water. There are presently no general guideline values for contaminant concentrations in groundwater or sediments. However, such values may emerge as separate environmental quality goals or, for example, as extensions of drinking water guidelines or guidelines for dredged marine sediments.

In order to improve the quality of risk assessments, site-specific procedures have been or are being developed for particular site categories, including:

- sawmills (chlorophenolic compounds and associated polychlorinated dioxins and furans and related halogenated aromatic compounds);
- contaminated sediments (polychlorinated aromatics);
- oil contaminated sites (BTEX compounds, particularly benzene, and MTBE);
- sites where chromium-copper-arsenic wood preservatives were used;
- shooting grounds (lead);
- sulphide mine waste tailing sites (several heavy metals);
- hazardous waste landfills.

Various computer-based exposure models have been used in assessment of Finnish contaminated sites; and, for some models, experience from their practical application has been collated. A research project is currently being planned on site-specific exposure and risk assessment models. Little has been done so far in Finland to use and improve probabilistic models for risk analysis, e.g. standard Monte Carlo or other uncertainty methods, although this is a key to more realistic assessments and to more informed management decisions. The validation of exposure and risk models for contaminated sites presents great challenges, given the order-of-magnitude uncertainties typically encountered, and the influence of exposures other than those attributed to the site.

In common with many other countries, contaminated site risk assessment in Finland has not yet been adequately integrated with risk management. There have been some attempts in this direction, e.g. in feasibility studies for clean-up and in relating risk reductions from clean-up options with costs. There is an increasing need to extend assessment in this direction, partly because of the need for cost-efficiency in remediation strategies and solutions. It would be beneficial to make better use of decision-oriented risk analysis methodologies developed in more advanced areas of environmental technology, e.g. radiation protection, safety engineering and health care. Multidimensional analysis of risks, costs, benefits, and the overall impact of risk management options, would provide a sounder basis for decision making at both the site-specific and regional levels.

France

France has no specific legislation concerning contaminated sites. The key policy document is a Ministerial Directive to the heads of Departments dated 3 December 1993 relating to the management of contaminated sites. This Directive, a part of the law of 19 July 1976 on environmental protection, defines the principles for a realistic soil clean-up policy. This should lead to the remediation of those polluted sites recognised as presenting a significant risk to human health and/or the environment.

The remediation of orphan sites is funded by a tax on hazardous industrial wastes (levied in 1998 at 40FF per tonne of industrial wastes treated in a collection installation) which was introduced in February 1995. The money raised from this tax (about 100 million FF in 1998) is allocated to site investigation and clean-up. A national committee is responsible for the management of the waste tax and has agreed to some 60 interventions at orphan sites. The Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) is in charge of collecting the industrial waste tax and implementing site investigation and clean-up.

France has six water agencies (agences de l'eau) that have decided to provide grants or low-interest loans for site investigation and clean-up within their operating period (1997 to 2000). Grants and loans amount to approximately 30% – 70% of total costs depending on the water resource area and the water agency involved.

France has a national procedure for identifying and assessing potentially contaminated sites. The first priority is a preliminary field visit in order to identify sites presenting immediate risks requiring emergency measures (e.g. leaking drums, flammable products etc.). If there are no immediate risks, or they have been dealt with, an initial diagnosis (soil study) follows. The objectives of the initial study are:

1) identification of potential pollution and a brief description of the likely impact on human health and the environment from past or present activities;
2) collection of information necessary to implement a simplified risk assessment in order to rank the need for intervention.

The soil study involves two principal steps:

- Step A: compile documentary evidence on potential pollution using readily accessible information, supplemented by one or more field visits;
- Step B: if necessary, brief additional field investigations to gather information that could not be obtained previously.

Step B of the initial diagnosis involves collecting data unavailable at the end of Step A but required to classify sites using a simplified risk assessment method. This will usually be limited to confirming pollution of the various media. The restricted investi-

gations should take account of the conceptual model developed at the end of Step A, use of resources in proportion to the size of the site, safety of personnel, and environmental protection. All information collected during the soil study will be used in a simplified risk assessment. However, it is not an aim at this stage to conduct investigations into the spatial distribution of pollution, its transfer mechanisms, the extent of damage or the choice of remediation techniques.

The objective of simplified risk assessment is to distinguish between sites that do not present significant risks to human health and the environment from those that could do so. This simplified assessment is conducted by considering human health and water resources as the principal receptors, as a function of the known uses of the site and its surroundings at the time. The simplified risk assessment uses a scoring method based on the fundamental risk assessment paradigm – source, pathway, receptor. Technical criteria have been defined for each component enabling them to be characterised on the basis of information obtained during the initial diagnosis; 49 criteria have been chosen in four categories:

1. potential hazard posed by the source;
2. potential for mobilisation and transfer of contaminants;
3. receptors;
4. observed impact.

Technical guidance for the next phase, in-depth diagnosis and detailed risk assessment, is still under discussion. However, the basic principles are as follows:

- risk assessment should take into account current and future uses of a site and its surroundings;
- receptors taken into account are humans, water resources, ecosystems and buildings;
- for human health risk assessment the maximum tolerable excess lifetime cancer risk to be used for defining remedial objectives is still under discussion. A theoretical risk of 10^{-5} could be set as a target value. A risk greater than 10^{-4} should be considered as unacceptable;
- assessment of groundwater pollution must reflect both present and future use. In particular, local water management schemes define the areas that should be protected as future resources for drinking water supply;
- risk assessment for ecosystems and buildings should proceed on a case-by-case basis, according to the current practical state-of-the-art;
- due to the relatively high uncertainty in the field of risk assessment, direct measurements should be performed before and after remediation in order to validate results.

Detailed risk assessment should enable identification of sites which present unacceptable risks to human health and other receptors, and which therefore require remedial action. Remedial objectives should be consistent with the defined land use of a site and its surroundings, and be both technically and economically realistic.

The proposed methodology for detailed risk assessment could, depending on the site, be carried out in two phases:

1) using generic scenarios of human exposure, currently being defined by the national ‘health and environment’ working group; and also taking account of possible risks to potable water (without, however, implementing complicated transfer models);
2) using specific exposure scenarios that are as realistic as possible for the site and its environment.

It is recognised that this approach still presents numerous uncertainties due to the complexity of the phenomena studied and gaps in current scientific knowledge. These uncertainties should therefore be analysed in order to understand the limitations of the approach used.

In summary, the main recommendations for the use of simplified risk assessment are:

- it must be cooperative between the different participants (site owner, consultants, regulator) in order to be effective;
- reliability of the available data should be taken into account. If the information is insufficient to attribute an overall score, the initial investigations must be extended;
- the development of French guideline values for soils is in progress. These are necessary to score the level of expected impact as a function of land use (residential with or without vegetable gardens, industrial, office use). Provisional guideline values have been defined based on foreign practice in order to start the regulatory studies on some 1500 active sites.

Regarding detailed risk assessment, it is planned that a Ministerial Directive on remedial objectives will be published in 1999.

Germany

The Federal Soil Conservation Act was ratified in Feb-

ruary 1998 and came into force in March 1999. By means of this Act the multiplicity of legal requirements and standards for soil remediation in different parts of Germany are replaced by national uniform criteria for risk assessment and clean-up. Uniform criteria will also provide investors with a measure of legal security and make it easier to calculate the risks arising from soil contamination. Suspected soil and groundwater contamination often acts as a stumbling block to urban regeneration and economic development. An important objective of the Federal Soil Conservation Act is to permit contaminated land to be kept in beneficial use wherever practicable, and hence reduce the pressure to develop on greenfield sites.

The special regulations in the Act concerning contaminated site management are consistent with current regulations in the *Länder* (federal states). They can be described as follows:

- competent state authorities are responsible for the official registration, investigation and risk assessment of all abandoned sites suspected of contamination. The authority can recover the costs of investigation from the person responsible;
- by means of uniform soil screening levels (trigger values) the responsible authority must decide on the need for further detailed investigation, or for immediate remedial measures. Soil screening levels trigger further investigation to confirm (or otherwise) that potentially dangerous concentrations of hazardous substances exist;
- as well as uniform soil screening levels, uniform action values (but not uniform clean-up standards) will also be prescribed when there is good scientific justification. Action levels indicate a hazard level that has to be addressed immediately without the need for further site investigation;
- decisions about the type and extent of remedial action will be made case by case depending on land use (present and future) and on the relevant receptors.

To help decision makers Appendix 2 of the Draft Ordinance on Soil Conservation and Existing Contaminated Sites contains the following proposed values:

- soil screening values for the direct soil-to-human pathway for different land uses: children's playgrounds; residential; parks and recreation; industrial and commercial;
- screening values for the pathway soil-to-edible plant;
- leachate screening levels for the soil-to-groundwater pathway, which are not land use-dependent;
- action values for the direct soil-to-human pathway;
- precaution values to obviate new soil pollution.

The screening and action levels are both risk-based. However, including all theoretically possible exposure pathways increases uncertainty and with it the chance of implausible results. It is therefore preferred to base levels on characteristic and simplified exposure scenarios, such as soil ingestion by children playing outdoors. Whenever feasible, action levels should be based on bioavailable soil concentrations.

Soil concentrations that exceed action levels *usually* lead to remedial action. *Usually* means that in some cases another conclusion could be justified, for example if the levels were based on assumptions that are inappropriate for the specific case. Concentrations that are between screening and action levels will require the competent authority to decide whether or not there is a danger; the authority will take into account the type of soil, the mobility of hazardous substances and other specific circumstances. Concentrations below screening levels imply that the site is not hazardous to public health or the environment.

According to the Basic Law (Articles 30, 83) responsibility for identification, risk assessment and remediation of soil contamination rests with the *Länder.* Although the details may vary according to the administrative structure in each state, the general procedures are very similar and involve identification and registration of suspected contaminated sites; investigation and risk assessment; remediation and/or monitoring. In Germany risk assessment is understood to mean the whole process of site evaluation following an initial historical investigation. Risk assessment is carried out case by case and decisions depend on the type of land use, the degree and extent of pollution, the relevant receptors and the existence of exposure pathways.

To eliminate geographic differences in legal requirements and soil standards a joint Federal/State Working Group has developed uniform, scientifically-based soil screening values in accordance with the Federal Soil Conservation Act. The Working Group issued a report on the derivation of screening values for 14 substances in the context of assessing human health risks. These play a key part in the draft Ordinance, as mentioned above. The soil screening levels are based on:

- a set of human toxicological reference dose (TRD) levels which give a virtually safe dose via ingestion or inhalation; and, based on this virtually safe dose, estimation of a body dose that indicates a certain level of risk to public health;

- exposure from ingestion or inhalation of soil based approximately on the 95th percentile intake of an exposed population;
- substance-specific considerations, e.g. taking account of bioavailability when possible, and checking calculated results against soil background values.

Soil screening levels are derived for individual substances. Effects resulting from combinations of substances have not been considered so far. However, the Working Group considered that 80% of the TRD should be reserved for general pollutant uptake via food, water and air, so that only 20% of the TRD is allocated to exposure from soil. For carcinogens, as a starting point for deriving trigger levels, a theoretical lifetime excess cancer risk of $5x10^{-5}$ is suggested for each individual substance.

While land use and receptor-specific trigger levels are to be regulated uniformly for the whole of Germany, such regulation is not envisaged for site-specific risk assessment methods. Legally prescribed procedures are not considered appropriate since they would not be able to take into account the special characteristics of specific contaminated sites. However, uniformly applicable principles are appropriate for site-specific assessment, which should be consistent with the principles used to derive trigger values.

The UMS system (U for environment, M for human health, S for pollutant substances) was developed as a methodological aid for site-specific risk assessment of contaminated sites, and for deciding on the need for remedial action. UMS uses quantitative exposure assessment methods to estimate the potential daily human intake of hazardous substances, and to compare this with the tolerable daily intake (TRD). Decisions on the need for remedial action are always determined in the context of background pollution levels in the case concerned.

In addition to UMS, the SISIM model was developed for simulating transfer of contaminants in the unsaturated zone. This model can be used in cases where leachate screening levels are exceeded, and allows a picture to be obtained of the quantity and mobility of contaminants in the unsaturated zone. The results of SISIM are the estimated concentrations of contaminants in soil and percolating soil water for every soil layer in time and space. Based on this information the threat to groundwater quality can be estimated.

Greece

In Greece, Environmental Law 1650/86 was enacted in 1986 and was designed to cover all aspects of environmental protection. In that law specific provisions were included regarding soil protection from the disposal of municipal and industrial wastes, and from excessive use of fertilisers and pesticides. Although no specific legislation, guidelines or standards exist for soil quality, there are several components in Greek law which refer directly or indirectly to control of soil and groundwater contamination.

The paucity of heavy industry and other production activities that give rise to hazardous wastes has restricted the number of contaminated sites in Greece. Such sites are more likely to be related to improper dumping of household and industrial wastes, to mining spoil and tailings ponds, to petroleum refining and storage sites, and to plants for wood impregnation. So far there has been no specific survey for the identification and registration of contaminated sites in Greece. According to the first inventory of household waste disposal sites in 1988, some 3500 sites were operating without any environmental protection measures, and about 1500 sites with limited measures.

Since 1990 all new sanitary landfill sites should follow the procedures defined in the Joint Ministerial Decision (JMD) 69269/5387/90. Waste disposal should be operated under continuous control, according to the environmental provisions set by the competent authorities. Any sanitary landfill site should be rehabilitated at the end of its operation, and the local authorities are responsible for restoration costs. Many old disposal sites, in which operations ceased before 1990, are known to cause significant pollution.

Hazardous and industrial waste disposal in Greece includes co-disposal in municipal landfills for those hazardous wastes which are similar in composition to household waste. Other types of hazardous waste may be stored in controlled places within the installation where wastes are produced or they may be exported for specialist disposal. The latter is applied in cases of high risk wastes such as PCBs, cyanide wastes and pesticides.

Two programmes are in progress for site selection and construction of treatment plants for the controlled disposal of hazardous wastes, one for northern Greece and one for southern Greece. There is also a study regarding installation of a treatment plant for liquid hazardous wastes and sludge produced from industries in the Attica and Viotia prefectures. The major problem to be faced concerns public acceptance of the proposed sites.

Research carried out by universities and research institutes has identified a number of industrially contaminated sites. Today a study is being planned by the Ministry of the Environment for the accurate registration of sites suspected of dumping hazardous waste.

In Greece, no national guidance documents on risk assessment currently exist for contaminated sites. Guidance documents have been developed by some organisations but they do not have general force. Generally, the risk assessment approach is site-specific and performed according to international (e.g. US Environmental Protection Agency) standards. In some cases Greek legislation requires certain procedures to be carried out. For example, for site investigation and analysis CEN methods are followed. This means that strategies for sampling and analysis should comply with CEN methods which are considered to have the authority of legislation. The choice of contaminants to be analysed is based on previous site usage and of known contamination incidents. For assessing the human toxicity of chemicals Greece mainly uses WHO Environmental Health Criteria documents and IARC Monographs for carcinogenic substances.

Ireland

Ireland lacks specific contaminated land legislation. However, existing legislation provides a considerable range of powers for dealing with contaminated land and has implications for any remedial actions that may be required. Existing legislation of particular importance includes:

- The Waste Management Act 1996;
- The Environmental Protection Agency Act 1992;
- The Local Government (Water Pollution) Acts 1977-1990;
- Building Control Act 1990; and
- The Air Pollution Act 1987.

A summary of how these Acts can be used to deal with contaminated sites follows.

The Waste Management Act 1996 confers powers on local authorities and the Environmental Protection Agency (EPA). These powers relate to land contamination (i.e. environmental pollution) arising as a result of waste disposal and waste recovery activities. Under the Act, the EPA has a wide range of statutory duties and powers relating to waste management. Two areas of particular importance in relation to contaminated land are waste licensing and the preparation of a National Hazardous Waste Management Plan (NHWMP). This plan is currently in preparation and should be adopted in 1999. The Plan will establish a framework for the management of sites that have been used in the past for disposal of hazardous waste. The NHWMP will be integrated with local authority waste management plans for their functional areas; and the management of pollution, risk assessment, and site remediation will be the responsibility of local authorities.

Section 22 of the Waste Management Act requires each local authority to prepare a waste management plan which must detail its approach to waste prevention, minimisation, recovery and disposal of waste within its functional area. The Waste Management (Planning) Regulations 1997 (SI no. 137) require that each Plan specifies the quantities of wastes arising within its functional area. Contaminated soil is a category of waste which should be quantified within the Plan and an indication of the nature of contamination is also required (i.e. hazardous or non-hazardous).

Under section 75 of the Environmental Protection Agency Act, the EPA has powers to specify quality objectives in relation to any environmental medium for the purposes of environmental protection. The EPA may also prepare guidelines on how and within what time scale these objectives should be achieved, identify public authorities or other bodies which may contribute to their achievement, assess the resources required, and arrange for the dissemination of relevant information. To date the EPA has published a discussion document on Environmental Quality Objectives (EQOs) and Standards (EQSs) for the aquatic environment and is currently preparing a discussion document on EQOs and EQSs for soils.

Although the Local Government (Water Pollution) Act 1977, and Local Government (Water Pollution) (Amendment) Act 1990 deal specifically with water, contaminated soils which have the potential to pollute surface and/or groundwater can be controlled under these Acts and associated Regulations. Local authorities have powers to issue a notice under section 12 (1) to any person having the custody or control of any polluting matter on premises in its functional area in order to prevent or control pollution of waters. The local authority can specify measures or actions required to be taken by the responsible person(s) to prevent polluting matter from entering waters.

Under section 16 (1) of the Air Pollution Act 1987 local authorities have powers to issue notices in order to prevent or to limit air pollution on the occupier of any premises from which there is an emission. In the context of contaminated land these powers may be applicable to sites undergoing remediation, particularly sites where volatile organic compounds are present or the potential for dust generation exists. Again, the power to issue Section 26 Notices has also been conferred on the EPA in relation to its Integrated Pollution Control (IPC) activities.

In line with other European countries, Ireland's approach to contaminated land encompasses pollution prevention, the 'polluter pays' principle, the precau-

tionary principle and the use of risk assessment to identify and prioritise sites requiring remedial action. This approach will initially be applied to the management of sites used for the disposal of hazardous waste and will then be applied to other types of contaminated sites. EQOs for soil, which will be based on the various uses to which soil can be put, will be met through the application of EQSs. EQSs will take the form of guidance values for chemical contaminants. Environmental management plans and programmes will be used to tackle issues of physical degradation, and diffuse impacts such as nitrate and phosphate pollution of water.

In relation to contaminated land management, the Agency is considering setting non-statutory guideline values for contaminants, both in soil and groundwater. It is proposed that these values will be derived from risk-based generic guideline values adopted in other European countries. The values will be tailored to meet Irish conditions and policies through a process of consultation with relevant bodies. It is envisaged that the guideline values will act as triggers to indicate whether further site-specific investigation and evaluation is required. Where generic guideline values are exceeded then a site-specific risk assessment would be required to determine the actual risks to human health and the environment posed by the site. On completion of site-specific risk assessment, decisions can then be made about appropriate actions taking into account fitness for use.

Italy

The National Plan for contaminated land remediation was updated by the Waste Management Act of February 1997. The Waste Act regulates private and public liabilities with respect to land remediation and provides a legislative framework for the following technical issues:

- acceptable limits for contaminant concentrations in different environmental media as a function of land use;
- guidelines for sample collection, preparation and analysis;
- general criteria for project design and remedial actions.

Whenever acceptable concentrations cannot be reached because of technological or economic constraints, other remedial actions in the form of containment measures, institutional controls or land use limitations are envisaged. Appropriate remedial actions are decided on the basis of site-specific assessments.

Inventories of potentially contaminated sites are compiled by the regional administrations, which are also responsible for prioritising remedial actions. Local authorities, i.e. the municipal and provincial administrations, are mainly responsible for approving and certifying remediation projects as well as providing institutional controls when needed.

The ‘polluter pays’ principle is always enforced whenever liable parties are identified. Remediation of contaminated sites ‘of national interest’ is the direct responsibility of the Ministry for the Environment and the National Agency for Protection of the Environment (ANPA). Sites of national interest are of three types:

- sites (generally large areas in old industrial settings) that are taken care of by ad hoc laws;
- sites spanning more than one regional territory;
- sites selected according to a scoring system based on comparative risk. Scores refer to contaminant nature, extent and concentrations; population and environmental vulnerability; ecological factors; social and economic parameters; and land use.

Proposals for remediation of sites of national interest are submitted to the Regions and to the Ministry for the Environment for approval and partial funding. ANPA and the Regional Agencies for Protection of the Environment are responsible for verifying the success of remediations.

The main general guidance documents used for conducting site-specific risk assessments have been the US Environmental Protection Agency’s *Risk Assessment Guidance for Superfund* and the ASTM *Risk Based Corrective Action* (RBCA) manual. For priority setting within individual regions, comparative risk assessment principles have been used.

The National Society for Standardisation within the Chemical Industry (UNICHIM) has published two manuals on risk assessment prepared by a working group comprising experts from industry, local authorities, universities, research institutions and ANPA. Manual no.175, published in 1994, reviewed the following subjects:

- national and international standards, regulations and technical guidelines;
- processes governing soil and aquifer contamination;
- identification, ranking and assessment of risks;
- safety considerations during site investigation and remediation;
- field investigation, sampling and analytical techniques;

- remediation strategies under emergency conditions;
- containment, treatment, remediation and clean-up technologies;
- remediation case studies.

The manual includes a survey of methods to assess soil and groundwater contamination and related human health risks. Basically three different approaches are reviewed:

1. comparison with background concentration levels;
2. comparison with quality standards or guidelines defined on an international, national or regional basis;
3. comparison with maximum acceptable contaminant levels derived by site-specific risk analysis.

Where an unacceptable risk is identified a procedure is used to define priority actions and clean-up objectives. Risks to human health are evaluated through exposure assessment of target populations or individuals, both for present and future exposure. Dose-response assessment (toxicity and carcinogenicity) is integrated with exposure assessment to provide a quantification and characterisation of risks. Clean-up objectives may be defined according to contaminant intake thresholds, or existing thresholds such as drinking water standards.

In Manual no.185, published in 1996, a tighter relationship between risk assessment approaches and regulatory implementation is envisaged. The emphasis is on more site-specific analysis, but screening levels and other prioritisation tools may be used when several sites need to be considered. The three criteria earlier identified in Manual no. 175 are proposed as the basis for a logical and comprehensive methodology:

1. the first level involves comparing contaminated soil analyses with tabulated soil quality standards according to different land uses. These standards are elaborated by the Regions on the basis of local environmental considerations as well as national and international standards;
2. the second level consists of a relative risk ranking to prioritise contaminated sites within each Region;
3. the third level consists of a site-specific risk analysis and is applied to priority sites, or whenever single contaminated sites need to be assessed and remediated. This type of risk assessment may be carried out in two stages, a worst case analysis followed by a more detailed and realistic analysis.

Clean-up objectives and remediation goals are set using the results of this three-level procedure.

Recently ANPA and the Regional Agencies for the Environment started an intensive programme to develop technical approaches for risk assessment and restoration of contaminated sites. Within this programme a risk-based tiered procedure for decision-making has been outlined. This tiered procedure envisages two simplified types of risk-based assessment, generic and site-specific, as tools for site screening and for defining clean-up objectives. Generic acceptability limits (i.e. screening/guideline values) for contaminants are defined according to a risk assessment approach including sensitive and less sensitive land uses. Soil and groundwater values are intended to act as national reference levels.

Different receptors and exposure pathways are considered through validated exposure and contaminant migration models. Protection of groundwater as a drinking water resource is accomplished by use of regulated water standards as well as appropriate soil values. Site-specific risk assessment is encouraged to ensure that clean-up objectives and remedial actions are appropriate for local exposure conditions.

The Netherlands

In The Netherlands, soil clean-up operations started early in the 1980s when an inventory of seriously contaminated sites was drawn up. In particular ongoing local-scale polluting activities were identified as requiring preventive measures. Large-scale diffuse sources also cause soil pollution but in general they do not lead to the creation of seriously contaminated sites. As a result, they do not show up in the inventory of sites for clean-up.

The underlying premise of the Soil Protection Act, which came into force in 1987, is that pollution of soil is not allowed. If a soil became polluted after the Act came into force then, in principle, the pollution should be removed irrespective of the risks. The ALARA principle (As Low as Reasonably Achievable) and the use of best available techniques are instruments that can be used to control soil pollution. In practice it is seldom possible or feasible to control or prevent all releases to soil. Therefore, the Act states that emissions and the resulting soil pollution can be tolerated so long as the soil quality does not decline (stand-still principle) and that the multifunctionality of the soil is not endangered. For the implementation of this policy, so-called target values or criteria related to target values are used. As long as the concentrations of pollutants in soil remain below the target values, the soil is considered multifunctional, i.e. fit for any land use, bearing in mind any limitations due to the natural composition of the soil.

If soil contamination occurred before 1987, the contamination still has to be managed; and if a site is seriously contaminated then a clean-up might be necessary. For a large number of substances, intervention values have been derived which represent seriously contaminated soil. Such soil has to be managed before, during, and after the clean-up. The management strategy adopted depends on local circumstances but should always be focused on the prevention of contaminant dispersion, the reduction of site-specific risks, and the improvement of soil quality. Social and economic factors also influence the way soil contamination is managed. In some cases it might be necessary to adapt the end-use of a site.

Current legislation requires that the polluter should pay for the cost of clean-up. If this is not possible then the owner of the contaminated site is responsible. In cases of so-called innocent owners, the clean-up is paid for by the authorities using public money. At the moment, this process is managed in a way which gives the owner a more central position in remedial action decisions including more responsibility for the cost.

The Ministry of Housing, Spatial Planning and the Environment (VROM) is responsible for defining general soil policy. The Soil Protection Act, and instruments based on the Act such as General Administrative Orders, soil quality objectives and procedures for estimating site-specific risks, are defined by the Ministry. The local authorities, provinces and municipalities are responsible for applying the Act and associated instruments, and deciding how best to deal with specific contaminated sites. The National Institute of Public Health and Environmental Protection (RIVM) provides the scientific basis for soil quality objectives and risk assessment procedures. The Technical Committee on Soil Protection (TCB) advises the Minister on the implementation of technical and scientifically based instruments in soil protection policy. The development of instruments such as quality objectives takes place in close cooperation with all relevant parties to ensure that they will be suitable for use and widely accepted. Because clean-up costs have to be borne primarily by polluters and site owners, special treaties have been developed between the Ministry and specific bodies such as railway companies and the trade organisation for laundries.

Risk-based soil quality objectives are an important instrument in Dutch soil policy, especially in relation to the clean-up of contaminated soils. Target values and intervention values have been established for about one hundred substances for soil and groundwater, and are related to the percentage of organic matter and clay in the soil. If target values are met, the soil is considered clean or multifunctional. If the average contaminant concentration in a minimum soil volume of 25 m^3 exceeds the intervention value, the contamination is classified as serious (in the case of groundwater contamination, a minimum volume of 100 m^3 applies). Target values are not related to a volume criterion at the moment, but this will probably occur in the near future. Recently, target values have been re-examined and, for a number of substances, new risk-based values were proposed. These are expected to come into force in 1999.

The target and intervention values are part of a general framework of risk-based environmental quality objectives. Exceeding such objectives indicates the potential for risk, assuming that exposure always occurs to its full extent. However, in practice full exposure will not always occur, and it is important to take local circumstances into account when estimating actual risks. At the time of writing the number of procedures for estimating actual risks is limited. The most advanced procedure developed is that used to determine the urgency for clean-up.

According to the Soil Protection Act the following questions should be answered in relation to the clean-up of contaminated sites:

1. is the site seriously contaminated?
2. is clean-up urgent?
3. when should clean-up start?
4. what is the clean-up objective?

Question 4 has been the subject of much discussion and debate in recent years. In the past, strategy has focused on clean-up resulting in a multifunctional soil unless the clean-up caused environmental problems, was impossible for technical reasons, or was too expensive. If a total clean-up appeared to be impossible the site was isolated, controlled and monitored (ICM approach). ICM solutions could involve partial soil excavation and could be related either to current or intended use of the soil. A phased approach to remediation was allowed so long as any immediate danger from the site was dealt with as soon as possible. In practice, the distinction between total clean-up and ICM was found to be too rigid and not cost-effective. Therefore other potential solutions were explored. Recently this resulted in a new strategy:

- for new sites (contaminated during and after 1987) a total clean-up should be performed;
- for old sites (contaminated before 1987) and with mobile contaminants, the contamination should be removed as far as possible in a cost-effective way;
- for old sites with non-mobile contaminants, the contamination should be removed to the extent nec-

essary, recognising the end-use of the site (function oriented approach).

The general outline of the new approach was adopted by the Dutch Parliament in 1997. Advice on how to deal with certain aspects of this approach (e.g. cost-effectiveness, criteria for mobility) will be defined in 1999.

The success of the Dutch system partly reflects the organisation of the process. In this context it is useful to summarise some important characteristics.

The distinction between scientific and political aspects

Research projects leading to soil quality objectives or risk assessment procedures are usually divided into scientific and political phases. In the scientific phase, objectives and procedures are derived in an objective manner to the extent possible in the light of scientific knowledge. In the political phase – the practical implications for soil policy are discussed including economic, financial and social factors.

Development of soil quality objectives and risk assessment procedures in close cooperation with other ministries, local authorities and other affected parties

In the Netherlands local authorities, provinces and municipalities are largely responsible for the use of instruments like soil quality objectives and risk assessment procedures. Other ministries may also have responsibilities. Therefore representatives from local authorities and other ministries are involved in projects from the beginning. Similarly, a policy will only work if it is accepted by the various parties that will use it or be affected by it. Therefore industry and environmental groups are involved in discussions at an early stage; and, as far as it is reasonable to do so, their interests are taken into account. They are also invited to contribute their scientific expertise.

Estimation of the consequences of instruments before they come into force

The acceptance of instruments to manage contamination depends to a large extent on the consequences. In relation to soil clean-up especially, the financial consequences can be very large. In order to prevent consequences that are unacceptable, it is important that these are anticipated before measures come into force. Usually such an analysis does not change the way that instruments are implemented in soil policy. However, sometimes a phased or alternative approach will be chosen on the basis of estimated consequences.

Norway

In Norway the most important provisions concerning pollution of the external environment are gathered into one law, the Pollution Control Act of 1981. This Act provides the government with the authority to regulate pollution with specific provisions for pollution of water, air and soil as well as noise and waste. The 'polluter pays' principle is an important component of the Pollution Control Act. If the original polluter cannot be identified or held responsible, the present landowner can be held liable for the cost of site investigation and remedial action.

The Norwegian Pollution Control Authority (NPCA) is responsible for the regulation of contaminated sites; most are dealt with directly by the NPCA with the regional authorities (counties) handling only a few cases. As well as controls under the Pollution Control Act, the Planning and Building Act requires that local authorities consider possible soil contamination prior to approving or licensing new construction projects or land developments. The national authorities have encouraged municipalities to use this law in their regulatory work, thus helping to reduce the number of construction projects which have to be stopped temporarily due to the discovery of soil contamination.

To assist in the regulation of contaminated sites in Norway a two-tiered decision model was developed and put into force in 1995. This model focuses on the need to address the sources, pathways and effects of contamination on different receptor groups such as humans, groundwater, nearby surface water (including fjords), and the soil environment. Generic target values were developed for the following compounds: arsenic, lead, cadmium, copper, chromium (total), nickel, zinc, mercury, cyanide (total and free), pesticides, benzene, ethyl benzene, toluene, xylene, total aromatics, PAHs (total or as benzo(a)pyrene toxic equivalents), mineral oil and PCBs. These target values, which relate only to the most vulnerable land use, are based on existing Danish and Dutch values for contaminated sites. For other land uses, or for occasions when target values are exceeded, a system of site-specific risk assessment is applied.

In 1991 the NPCA published a report entitled *Technical Guidelines for Environmental Soil Investigations*. This is a practical guide on sampling techniques, sample pretreatment methods, and reporting routines. Work to establish guidelines for chemical analysis methods was conducted jointly in the Nordic countries, and the results from a round-robin test have been published in *Nordic Guidelines for Chemical Analysis of Contaminated Soil*. This includes guidance on the analysis of contaminated soils for toxic metals, chlorinated phenols, creosote, VOCs (volatile organic compounds), PCBs, THC (Total Hydrocarbons), and

PAHs. An abbreviated version with modified recommendations has been summarised by the NPCA.

The management of contaminated land is currently conducted according to preliminary guidelines published by the NPCA: *Management of Contaminated Land, Preliminary Guidelines for Executive Procedures*. During interim implementation of the guidelines, the NPCA identified the need for improvements and for more detailed guidance to reduce the variability in approach used by different consultancies and local authorities. It was therefore proposed to develop the general regulations for assessment and clean-up of contaminated sites, and to simplify the existing practice of central environmental management of contaminated sites. The new regulations will present simplified procedures in accordance with the Planning and Building Act. The guidelines will cover site investigation, risk assessment and remedial actions including excavation and *in situ* treatment. In addition, the revised guidelines will include methods for quality control.

In order to effect this revision to the guidelines, a national R&D project was established in 1996 focusing on risk assessment tools and the development of a permanent set of soil quality criteria for contaminated sites. The consultancy firm Aquateam and the Norwegian Geotechnical Institute are working jointly on the revised guidelines, with funding from the Norwegian Research Council and the NPCA. Scheduled for publication in 1999, they incorporate a three-tiered approach. In tier 1 assessment the point of exposure is assumed to be the source, and generic soil quality criteria for the most vulnerable land use are used as acceptance criteria. In tier 2 assessment site-specific acceptance criteria can be developed using a set of algorithms provided, and multiple points of exposure are considered. Tier 3 assessment involves further investigation and the use of more fully developed transport and fate models.

The generic soil quality criteria have been developed along the lines of the Dutch target values and Swedish values for the most vulnerable land use. However, the lack of well documented data on terrestrial ecotoxicity results in target values for some substances being below background values in Norwegian soils. Some pragmatic adjustments have therefore been necessary.

Portugal

Portugal has not yet compiled data on contaminated sites, nor established national methodologies, criteria or explicit risk procedures for their assessment and remediation. In response to these needs the government created in 1997 (by Decree Law no. 236/97) a Soil Pollution Development Centre, integrated with the Waste Institute. This Institute is now working on the definition of a strategy for contaminated site management, and is compiling information from European and North American countries on the following subjects:

- contaminated land policy;
- methodologies for registering contaminated sites;
- criteria and risk assessment procedures for the assessment of contamination and for deciding on appropriate remediation objectives;
- procedures for the evaluation of remedial alternatives;
- risk-based soil screening values;
- specific legislation.

The Portuguese approach to contaminated site management may be illustrated by two case studies, the Estarreja's Chemical Complex and the Expo '98 site in Lisbon. The first prompted a major study *Methodologies for the Remediation of Contaminated Groundwater and Soils* (April 1994) with the primary objective of evaluating the nature and extent of contamination in the area surrounding Estarreja's Chemical Complex. Short-term pollution control measures were also proposed.

The 1998 World Exposition site in Lisbon prompted the first large-scale remediation of a contaminated site in Portugal, starting in 1994. The site was previously occupied by a petroleum refinery and storage tanks, a sulphuric acid plant, a thermal cracking unit and a landfill. The solution accepted for the remediation was excavation of the contaminated soils and their deposition in mono-landfills. The main problem in effecting this remedial action was in deriving clean-up criteria, since Portugal did not have legal standards to impose. To solve that problem the 'Interim Canadian Environmental Quality Criteria for Contaminated Sites' were adopted which take into consideration future land use and appropriate human exposure conditions. The criteria were fully supported by the Portuguese Minister for the Environment. At present Portugal still uses the Canadian criteria as guidance for establishing soil and groundwater clean-up goals, but in the near future intends to develop national procedures for land use-based assessment and remediation of contaminated sites. Risk assessment methodology will be fundamental to this.

In spite of not yet having compiled data on contaminated sites, sufficient information is available in Portugal to make a preliminary identification and characterisation of many sites, namely those related to existing industrial areas and uncontrolled waste deposits. There is an action plan to eliminate open dumps

which are mainly used for municipal wastes but also in some cases for industrial wastes. The plan provides for their sealing or the recovery of non-occupied parts of those dumps according to the standards of the proposed EU landfill directive. A monitoring system is also being set up for future control and classification of sites. Preliminary identification of contaminated sites is being done by various environmental organisations, supported by the Geotechnical Department at the Laboratório Nacional de Engenharia Civil.

Portugal does not have a specific fund to finance investigation and clean-up of contaminated sites. Investigations are funded by general environmental programmes. According to legislation (Framework Law on the Environment) the costs involved in remediating contaminated sites must be paid by the polluter. However, in some circumstances the government envisages paying part of the costs through public funds, mainly when it is difficult to share the responsibilities.

Spain

The Wastes Law (10/1998) was approved by the Spanish Parliament in April 1998. The Law transposes into Spanish legislation the fundamental aspects of EU Directive 91/156 relating to wastes. Soil contamination is specifically addressed in two articles. The Law also fulfils certain obligations concerning integrated pollution control in advance of the 1999 deadline for implementing the Directive.

The Wastes Law represents a notable advance in Spain because the concept of contaminated soil is defined on the basis of risks to human health and ecosystems. The principles established in the Wastes Law should, in the future, form the basis for a specific law about soil protection. In addition, special emphasis is put on the principle of sustainability by placing particular importance on waste prevention, waste treatment and the obligation of polluters to repair any harm caused. Sanctions against owners and waste managers are increased to the point of being able to limit factory production if it is proved that excessive wastes are being produced, when this could be avoided or reduced by the application of cleaner technology.

Until recently, the only possible way to prosecute contamination-related crime was under the now repealed Toxic and Dangerous Wastes Law of 1986. Nevertheless there were many ways to evade prosecution in cases of infringement. These were reduced following approval of the new Penal Code. In particular Chapter 16, Articles 319 to 340, makes reference to protection of cultural heritage and the environment. Nevertheless, it was often cheaper to pay a fine for environmental damages than to pay for remediating or repairing the damage caused.

In 1989 the central government approved the Industrial Wastes Plan, although the autonomous regional governments have constitutional responsibility for environmental management and must put the Plan into effect. Those regions most seriously affected by industrial development, such as Cataluña, Asturias, País Vasco (Basque Country) and Galicia, contain the most contaminated sites and have initiated actions to improve waste management. However they are limited by the scarcity of human and financial resources.

Meanwhile the central government, in co-ordination with the autonomous regional governments, began to identify potentially contaminated sites in order to develop a National Inventory. Up to 18 000 industrial facilities were selected based on the materials used, the size of the company and the potentially contaminative nature of the processes. All of those sites were considered to be potentially contaminated. All sites where contamination is proved are included in the National Inventory, grouped according to Autonomous Community.

Based on information from these studies, and using Dutch guidance values, the first two phases of the National Inventory have been compiled. Of the sites examined 4900 have been found to be potentially contaminated and 390 of these have been investigated in detail. A risk assessment has been prepared for each site using matrices to assess the different conditions of toxicity, contaminant mobility and risk to receptors. Based on this evaluation, actions in the short-, medium- or long-term have been taken or scheduled. At the time of writing, the third phase of the Inventory is being considered in some Autonomous Communities to re-assess the risks from selected sites identified in previous phases, and to add other sites not previously detected. On completion of this work very detailed information on the extent of the contaminated sites problem in Spain will be available.

In order to tackle the problem effectively, in February 1995 the central government approved the National Plan for Contaminated Sites Remediation. The duration of the Plan is to the year 2005. It is planned to characterise 1650 additional sites during the eleven years of the Plan. In addition, 275 contaminated sites are to be remediated, 77 of which are presently in the design phase or under way. The central government's Environment Ministry has signed bilateral contracts with the 17 Autonomous Communities to develop the Plan, with each providing 50% of the funding for remediation of publicly owned sites. The Autonomous Communities are responsible for formally contracting remediation works and monitoring their progress. Responsibility for remediation continues beyond the point when a site is cleaned up to the

required level for its anticipated use. Some funds are retained to control and maintain remediated sites, to guarantee that they remain in good condition, or to improve those sites that have deteriorated. This precaution is especially important for those sites that have been remediated with in situ technologies.

An important aspect of the Wastes Law, included in the Contaminated Soils Recovery Plan, is the requirement to derive screening/guideline values appropriate to the specific soil characteristics of each Autonomous Community rather than using values developed in other countries. Sampling and analytical methods will be standardised through technical guidance.

Each autonomous government has legislative authority over its own territory, and it can adapt and extend the basic legislation of the central government so long as it does not distort its intent. Because of regional differences in the characteristics of contaminated soils, some autonomous communities such as the Basque Country, Cataluña, Galicia and Castilla-León have established their own criteria for soil remediation. As an example, the management of contaminated sites in the Basque Country is briefly described below.

The Environmental Protection Act of the Basque Country (March 1998) constitutes the legal framework for addressing the problem of contaminated land. It includes a specific chapter concerning soil protection and remediation. While the text focuses on the recovery of previously contaminated soil, prevention of future contamination is also addressed.

The Basque Country takes a 'fitness for purpose' approach to the management of contaminated sites in which potential land use depends on the degree of contamination. Accordingly, soil quality is defined on the basis of risk assessment for protected targets (human health and the environment) and intended land uses. Two complementary instruments have been developed for risk assessment in order to achieve a cost-effective approach to contaminated site investigation:

- soil screening values known as Indicative Values for Assessment (VIEs). They are land use dependent and provide a generic assessment that will allow essentially risk-free soils to be differentiated from soils that pose or could potentially pose risks for the intended use. They are applied in the exploratory phase of an investigation; based on them, the competent authority must decide if there is a need for further detailed investigation or, in some cases, if immediate measures are warranted. Three levels have been established. The first, VIE-A, is derived on the basis of concentrations found in soils with little anthropogenic influence and therefore involving no significant risk for any likely soil use. The second, VIE-B, represents the level at which more detailed consideration of risks is required; and the third, VIE-C, is the value at which the risk becomes unacceptable;
  whereas these values could also be used as remediation targets, that would often be unrealistic because they would be more restrictive than the limits established as a result of site-specific risk assessments;
- a general methodology for site-specific risk assessment is provided, the aim of which is to determine the extent and nature of risks for both present and future receptors taking into account land use and site characteristics. Final decisions on land use restrictions and/or the kind and extent of remediation will be made on a case by case basis using risk assessment results, together with an evaluation of technology cost-effectiveness.

Sweden

In October 1995 the Swedish Environmental Protection Agency (EPA) presented the Swedish government with a remediation action plan. The purpose of the plan was to establish the long-term direction of site remediation work, to propose specific goals over a five-year period, and to identify the actions necessary to fulfil Sweden's site remediation needs. The action plan is summarised in English in the EPA's report *We're Well on the Way.*

A contaminated site is defined as 'any land, water, building and installation which is contaminated to the extent that it can pose a risk for human health or for the environment'. The contamination comes from point sources and the levels of contaminants should considerably exceed the background levels in the region. This definition also includes contaminated sediments in surface waters. Today it is estimated that there are some 22 000 contaminated sites in Sweden (including petrol stations, military sites and municipal waste disposal sites) of which about 12 000 have been identified.

As of 1 January 1999 Sweden has a new environmental law, the Environmental Code. The law includes:

- an obligation to report and make public any detected contamination of land or water;
- the possibility to register property and impose restrictions on land use;
- rules on liability for the investigation and remediation of contaminated land. The liability rests in the first place with the person who caused the pollution, and then with the person who owns the contaminated land.

Risk assessment involves, in this context, identifying and describing the risk of adverse effects on human health or the environment from a given site. Risk assessment may also include a discussion of how clean the site should be in order not to present a threat to man or the environment. The assessment should cover both the present and the future, and should include soil, groundwater, sediment and surface water. Risk assessments are made without concern for cost, technology, etc.

A risk assessment can be made with different levels of ambition, depending on its purpose and the quality of the available data. The same principles and risk criteria should be applied independently of the ambition level. The assessment should be based on high-end (but not implausible) exposure scenarios. Large uncertainties in the quality and amount of available data inevitably result in a conservative risk assessment. However, the worst case scenario often greatly overestimates the risk.

The Swedish EPA has developed guideline values for 36 contaminants or contaminant groups in soil. For each substance guideline values are developed for three different types of land use:

1. land with sensitive use, e.g. residential areas, kindergartens, agriculture, together with groundwater abstraction;
2. land with less sensitive use, e.g. offices, industries, roads, car-parks, but still with groundwater abstraction;
3. land with less sensitive use as above but with no groundwater abstraction.

The generic values have been derived using a Swedish exposure model based on similar models and data developed by other countries and international organisations. Data were chosen, and in some cases adapted, so that the resulting values are appropriate for Swedish conditions regarding geology, exposure, sensitivity and policy. The main report describing how to use the guideline values is written in Swedish, although a summary report describing the model and data used for developing guideline values is published in English.

In 1997 the Swedish Petroleum Institute (SPI) signed an agreement whereby they took responsibility for the remediation of all petrol stations that had been closed down between 1969 and 1994. The structure of the agreement and the remediation programme is similar to those in Denmark and Finland. Several thousand closed petrol stations will be remediated over the next 10–15 years.

Switzerland

In Switzerland the identification, assessment, remediation and financing of contaminated sites is regulated by the Federal Environment Protection Law (1983, revised December 1995) and the Ordinance relating to the clean-up of contaminated sites (August 1998). These ensure a systematic approach to the assessment and remediation of contaminated sites throughout the country. The main focus for remedial activities is on urgent cases, often discovered through redevelopment.

The policy of the Swiss government has the following objectives with regard to contaminated sites:

- to stop emissions at source. Remediation criteria are based on emissions that lead to unacceptable impacts on water, air or soil. Decontamination, containment and use-restrictions for the soil are therefore all acceptable as remediation measures;
- cooperation between polluters and authorities, who are encouraged to work together under agreements instead of needing a legal ruling. Agreements with various industry sectors are encouraged;
- legal equality through harmonized criteria (e.g. intervention values, remediation targets, leachate tests); uniform requirements for the compilation and management of registers, and for planning and executing site investigations, monitoring and remediation projects;
- prevention of new risks. Building activities on contaminated sites are permitted only if it can be demonstrated that the site does not need remediation, that the project will not hinder future remediation, or that the site will be remediated in the course of the project. Containment measures have to be effective in the long-term, controllable, reparable and financially guaranteed;
- in general the costs of remedial measures should be borne by the polluter. However, the owner of a site is excepted from bearing the costs if he or she could not have had knowledge of the contamination, did not stand to gain from it, and will not stand to gain from the remediation. The authorities will rule on the apportionment of costs if those with an obligation to remediate so require;
- because many contaminated sites are orphan sites, the Federal Government has created a fund to pay for their remediation. This will be achieved by introducing a levy on landfills (up to 20% of the average landfill price) in order to finance remediation projects where the polluter cannot be identified or cannot pay, or where landfills containing domestic waste have to be remediated. The annual budget of this fund is planned to be in the region of 20–30m ECU.

According to current estimates the registers of polluted sites will finally include some 50 000 sites. About 3500 of these are likely to require remediation. The overall cost will be more than 3000 million ECU.

In order to identify the small number of dangerously polluted sites within the large number of contaminated sites, a step-by-step investigation is required. First the Cantons have to draw up a register of landfills and other polluted sites and decide which sites must be investigated most urgently. These registers will be available to the public. A decision to take remedial action will require a site-specific risk analysis based on interactions between the site and the environment, mainly groundwater, surface water, soil and air, taking into account potential for transport and barriers. Intervention values for leachate and air have been derived based on human toxicity consistent with the relevant laws concerning water and soil.

The owner of a polluted site is obliged to undertake an historical review and technical site investigation based on a programme that has been approved by the authority. In order to evaluate if there is a need for remediation or monitoring, the authority has to consider both emissions from the site as well as harmful effects on the environment. The general objective is that there should be no need for further remediation following clean-up. But other criteria such as technological feasibility, ecological sustainability and the costs of remedial action must also be considered. Sites cannot always be returned to their natural condition. Sometimes the target criteria only guarantee the protection and maintenance of the affected environmental media in their current use.

United Kingdom

In the United Kingdom Part IIA of the Environmental Protection Act 1990 (which is due to come into force in 1999) provides a new regime for the control of specific threats to health or the environment from existing land contamination. Contaminated land is identified on the basis of risk assessment. Within the meaning of the Act, land is 'contaminated land' where it appears to the regulatory authority, by reason of substances in, or under the land, that: 'a) significant harm is being caused or there is a significant possibility of such harm being caused; or b) pollution of controlled waters is being, or is likely to be, caused.'

The main regulators will be the local authorities who already have responsibility for dealing with effects on public health from land contamination, and for controlling developments on or near contaminated sites. The Environment Agency in England and Wales (and the Scottish Environment Protection Agency in Scotland) will have specific responsibilities for dealing with land designated as special sites. Current proposals describe special sites as contaminated land which:

- causes serious water pollution (e.g. results in pollution of major aquifers by List 1 substances as listed in the Groundwater Directive);
- might be difficult to remediate due to the presence of certain specific substances (e.g. an acid tar lagoon);
- is already regulated by the Environment Agency (e.g. an oil refinery);
- would be best served by a single point of contact (e.g. land occupied by the Ministry of Defence).

The UK follows the widely recognised source-pathway-receptor concept for assessing risks from contaminated land. A phased approach is preferred for the collection of site data, with early formulation of a conceptual model which can be developed as further data are gathered. Importance is placed on thorough assessment of all data about a site, and on making defensible decisions on risks based on appropriate and sufficient data.

For many years the UK has operated an approach to contaminated land risk assessment in which precautionary threshold trigger values are used as screening levels for some of the commoner soil contaminants. Detailed site-specific risk assessment, based on exposure and toxicity assessments, is used where these trigger values are not available, are not appropriate, or where particularly complex or sensitive site circumstances require it. In the context of direct human health risks these trigger values are being replaced by guideline values; these are derived employing the same procedures and algorithms used in detailed site-specific risk assessment, but applied to typical land scenarios characterised by specific exposure assumptions. Guideline values may therefore be used for risk assessment as long as the site assessor is satisfied that:

- the assumptions underlying the values are relevant to the source-pathway-receptor circumstances of the site in question;
- any other conditions relevant to use of the values have been observed (e.g. the sampling regime and the methods of sample preparation and analysis);
- appropriate adjustments have been made to allow for differences between the circumstances of the land in question and those assumed in deriving the guideline values.

To assist in making these judgements, and to reflect the suitable for use policy, separate guideline values are derived for different classes of land use (residen-

tial, recreational, commercial/industrial). Also, where appropriate, guideline values are derived as functions of soil type, soil pH, soil organic matter, etc. When guideline values are not available or their use is not appropriate, other risk assessment methods may be used so long as they are appropriate, authoritative and scientifically based.

It is more difficult to derive generic soil guidelines for groundwater protection. This is because most of the key variables (thickness and attenuating capacity of soil and bedrock, depth to water table, proximity to abstraction points, etc.) are highly site-specific. The Environment Agency has recently developed guidance on a tiered approach to assessing risks to groundwater. This includes simple screening approaches and progressively more sophisticated risk assessment methods for use where the circumstances justify the additional cost. The new guidance will emphasise the importance of an adequate conceptual model of the local and regional hydrology.

In some circumstances it is necessary to consider harm to or interference with ecosystems and habitats protected under the Wild Life and Countryside Act 1981, EC Directive 79/409/EEC on the Conservation of Wild Birds, and the Habitat Directive 92/43/EEC. The new legislation specifically identifies certain designated sites that require regulation by the Environment Agency where they have been defined as contaminated land under the Act. Risk assessment considerations for such sites are, of course, highly site-specific.

Some soil contaminants may adversely affect building materials. Within the UK this issue is generally treated by reference to generic guideline values, although it is recognised that there are currently relatively few useful data on the effects of hazardous substances on building materials and structures.

In recent years, it has been recognised that more consistency in detailed risk assessment methods would be beneficial. Therefore, in parallel with developing work on models and guideline values for risk assessment, research has focused on developing procedural guidance to be followed when dealing with contaminated sites. These procedures set out the required activities, and explain the relationships between (and how to use) the various technical models and guidance available. The procedural guidance will not be mandatory but will set out UK good practice. It will be applicable to all relevant parties, including regulators, industry, landowners, developers and professionals.

CONCLUSIONS

Within Europe the responses of governments, industry and the public to the problems posed by contaminated land have differed from country to country, both in nature and in relative timing. The UK, for example, was a pioneer in its early use of soil trigger concentrations as a decision-support tool in risk assessment. However, more recent efforts to provide a specific legal framework for managing land contamination have been dogged by delays. At the time of writing, Part IIA of the Environmental Protection Act 1990 (as inserted by section 57 of the Environment Act 1995) is still not in force, and a large quantity of related statutory and technical guidance remains unpublished.

In contrast Denmark's Contaminated Sites Act dates back to 1983. However, the Act and its subsequent revisions raised considerable problems for some innocent home owners. Therefore, as a supplement to the Act, a special system for remediation of residential sites was introduced in 1993 with the Act on Economic Blight to Family Housing on Contaminated Land (popularly known as the Loss of Value Act).

Germany was another pioneer in establishing systems for identifying, assessing and dealing with land contamination. However, a multiplicity of legal requirements and standards for soil remediation evolved in different parts of Germany. It was no mean achievement politically to persuade the various Länder and city authorities to adopt uniform risk assessment criteria under the Federal Soil Conservation Act, which came into force in March 1999.

In The Netherlands public concern following the Lekkerkerk incident led to an inventory of seriously contaminated sites being drawn up in the early 1980s. Dutch approaches to assessment and remediation of contaminated land have been very influential internationally, and Dutch generic guideline values (A, B, C values and their successors) have been used, and sometimes misused, in many other countries. In 1997 the Dutch policy of cleaning up contaminated sites for multifunctional use was replaced by the less rigid fitness-for-use approach favoured by most other European countries.

Not all European countries have evolved specific legislation for contaminated land. In France, for example, the key policy document is a Ministerial Directive, dated December 1993, which is part of a very general 1976 law on environmental protection. This has proved to be a suitable framework for regulating and providing guidance on contaminated sites. Remediation of orphan sites is funded by a tax on hazardous industrial waste which was introduced in February 1995. The French water agencies (Agences de l'Eau) also provide grants and low interest loans for site investigation and clean-up.

Portugal, in contrast, is a relative late-comer and has not yet compiled data on contaminated sites, nor established national methodologies or explicit criteria for their assessment and remediation. In response to these needs the Portuguese Government has recently established a Soil Pollution Development Centre, integrated with the Waste Institute. The Institute is now working on a strategy for contaminated site management, building on information and experience from other countries as well as Portuguese experience of major site remediation (e.g. the Expo '98 site in Lisbon).

There are certain fundamental principles on which all 16 countries participating in the CARACAS project appear to agree:

- the need to prevent or limit future pollution;
- the 'polluter pays' principle, usually with a mechanism for helping innocent land owners;
- the precautionary principle;
- the use of risk-based philosophy for identifying, prioritising and assessing the need for remedial action.

Nevertheless, in spite of a convergence of philosophy, there appear to be large differences in the practice of dealing with land contamination in the various countries. There is a distinct lack of research on these differences and their implications, but they appear to include: the extent to which the designs of site investigation and risk assessment are integrated, and the role of statistically-based data quality objectives in those designs; the use of generic guideline values as decision-support tools, and the methods for deriving such values; whether or not socio-economic considerations are factored into guideline values and other risk assessment methodologies; decision-support procedures for identifying optimal remedial strategies; and procedures for communicating about risks and benefits to relevant stakeholders.

These differences inevitably affect the cost of dealing with land contamination from one country to another. Such cost differentials, in turn, will affect company profits, business confidence, attractiveness to inward investors etc. Differences in risk management outcome might also affect public health and levels of ecosystem protection and/or the perception of these.

A major issue for all industrialised countries is how to reduce the cost of dealing with land contamination without compromising public health and water quality, or business confidence in the benefits of land regeneration and sustainable use of soil. These issues are being addressed in a new concerted action project (CLARINET, the Contaminated Land Rehabilitation Network for Environmental Technologies) which started in July 1998. Like CARACAS, it is also funded under the CEC Environment and Climate Programme and by accompanying measures of the participating countries. The primary objective of CLARINET is to develop recommendations for effective, and cost-effective, rehabilitation of contaminated sites in Europe focusing on socio-economic as well as technical issues.

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