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Design criteria for a worldwide directory of radioactively contaminated sites (DRCS)

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FOREWORD

The IAEA attaches great importance to the dissemination of information that can assist Member States with the development, implementation, maintenance and continuous improvement of systems, programmes and activities that support the nuclear fuel cycle and nuclear applications, including the legacy of past practices and accidents.

In response to such needs, the IAEA has initiated the development of a worldwide Directory of Radioactively Contaminated Sites (DRCS). The DRCS was started by issuing questionnaires to the Member States in 1996 concerning the state of knowledge on radioactive sites on their territories. The DRCS covers *inter alia* environmental contamination arising from past practices, such as production and processing of nuclear materials, the mining and milling of uranium and other ores bearing radionuclides, weapons testing, inadequate waste management, and from accidents involving nuclear materials. The tasks are also complemented by activities addressing specific origins of contamination, such as technically enhanced naturally occurring radioactive materials (TENORMs).

The DRCS is one element in the comprehensive, ongoing IAEA programme on environmental restoration of radioactively contaminated sites. The programme covers both technical and management issues:

- factors important for formulating a strategy for environmental restoration;
- site characterization techniques and strategies;
- assessment of remediation technologies;
- assessment of technical options for clean-up of contaminated media;
- post-restoration compliance monitoring;
- non-technical factors influencing the decision making process in restoration;
- assessment of the costs of restoration measures;
- remediation of low-level disperse radioactive contaminations in the environment.

The IAEA wishes to express its thanks to all participants in the work. Special thanks are due to V. Popov, Kurtchatov Institute, Moscow, who under a special service agreement helped to develop a prototype database. The IAEA officers responsible for organising the questionnaire were D. Clark and M. Hagood, while Z. Dlouhy worked on early drafts. The work on the prototype database was organised, and the final report was compiled by W.E. Falck of the Division of Nuclear Fuel Cycle and Waste Management.

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1. INTRODUCTION

1.1. Background information

The evolution of radioactive waste management is, fundamentally, no different than the evolution of waste management in other industrial sectors, such as the chemical industry. Like waste management in other sectors, radioactive waste management was not a high priority in the early days of nuclear research and development. Now it is often viewed as a critical factor that helped decide the fate of the nuclear industry in some Member States and it could help decide the fate of the nuclear industry in others. Like other industries, radioactive waste management has evolved over decades where initially little attention was paid to the effect of industries on the environment but now "sustainable development" is the order of the day.

Thus, in recent years the political and social climate in many countries favours action towards a cleaner environment. This may entail removal, as much as feasible, of sources that would cause contamination and hence increase the risks to humans and the surrounding environment. Radiological risks to humans and the environment can result from a variety of activities, some of which are related to nuclear applications, while others are related to non-nuclear activities. In most Member States, the general public is aware of the consequences of nuclear weapon testing, radiological accidents and of industries handling radioactive materials intentionally. This trend became even more pronounced with political changes in many East European countries, which strongly enhanced their efforts towards a cleaner environment and sustainable development as a long-term perspective, as supported on the highest political level by the UN Member States in Rio de Janeiro in 1992 [1].

The public perception of nuclear energy and of the use of radioactive substances in various fields of human activities is closely associated with the requirement of well-grounded and comprehensive information on conditions of those sites where the people live, work and spend their time. Today it is generally recognized that contaminated sites may present a hazard to the public health and the surrounding environment. The need for remedial and restoration action arises from the exceeding of acceptable exposure, or the risk of this to happen. What is considered to be acceptable is laid down in various international standards and national legislation. The public may seek a solution of the contamination problem and solicits active participation in decisions about the future of such sites.

In this context it is useful to recall Article VIII of the Statute of the IAEA, entitled "Exchange of Information", which states:

> *A. Each member should make available such information as would, in the judgement of the member, be helpful to the Agency.*
> *B. Each member shall make available to the Agency all scientific information developed as a result of assistance extended by the Agency pursuant to Article XI.*
> *C. The Agency shall assemble and make available in an accessible form the information made available to it under paragraphs A and B of this article. It shall take positive steps to encourage the exchange among its members of information relating to the nature and peaceful uses of atomic energy and shall serve as an intermediary among its members for this purpose.*

In addition to the above statements about the importance of information exchange, the Medium Term Strategy for the IAEA states:

The challenge for the Agency in the medium term is threefold:

- *to understand how the needs and interests of Member States are changing so as to be able to respond by focusing on the appropriate nuclear technologies;*
- *to contribute to the objective assessment of the use of nuclear technologies and to assist Member States in the safe application of those technologies that continue to have a comparative advantage;*
- *to play a catalytic role in the international effort to maintain and increase knowledge,*
- *understanding and expertise in the nuclear field, particularly through the collection and dissemination of scientific information and the transfer of technology.*

As a response to this development, the International Atomic Energy Agency, within its Environmental Restoration Programme, launched a project in 1996 aimed at development of a worldwide Directory of Radioactively Contaminated Sites (DRCS). The aim was to collect data about radioactively contaminated sites and pertinent restoration activities. To be included were sites, which, for various reasons (legal, real or potential impacts on human health, reuse of the site, socio-economic or political aspects) have required or, in the future, may require environmental restoration. It was expected that Member States would benefit from the information contained in the directory because such information may enable them to select, by inter-comparison, strategies and optimum remediation technologies applicable to their sites. IAEA technical co-operation and research programmes, as well as direct assistance to Member States were to be an integral part of the overall project.

When implementing this project, as a first step the IAEA developed and distributed to Member States a questionnaire requesting identification of contaminated sites [2] (see Section 5.3.1). The primary intention was to prepare a comprehensive directory based on information about contaminated sites collected from a number of Member States. The survey explicitly addressed sites contaminated with radioactivity as a result of

(a) nuclear or radiological accidents
(b) nuclear weapons production and testing
(c) poor waste management and disposal practices
(d) industrial manufacturing involving radioactive materials
(e) conventional mining and milling of ores resulting in radioactive residues.

Thirty-eight Member States responded to the questionnaire, of which 24 stated that no radioactive contamination, within the designated scope, was present on their territory. Reports from the other 14 Member States then provided a spectrum of site characteristics, which was considered a useful starting point for the directory development.

After reviewing thoroughly the results of its previous efforts, the IAEA decided, in a first phase until the year 2000, to re-define the purpose and structure of the directory and to start collating information on contaminated sites worldwide from freely available sources, in addition to that available through the questionnaire. It is envisaged to continue working towards a more comprehensive international Directory of Radioactively Contaminated Sites after the year 2000.

1.2. Objectives

The present publication attempts to fulfil two main objectives:

(a) to describe the activities and underlying considerations and concepts for the development by the IAEA of a worldwide Directory of Radioactively Contaminated Sites;
(b) to give some recommendations for the development of such directories at the Member State level.

In addition to a discussion of the conceptual considerations on the design of an IAEA-level directory, the results of previous efforts on data collation are presented.

In addition to being a directory, the DRCS also intends to collate technical information on remedial actions taken or proposed, thus providing examples for consultation in similar cases. Hence, the information available in such a Directory is intended to provide decision makers with a useful reference frame for their own actions. In this, the IAEA attempts to assume the role of a clearing-house of information pertinent to characterization of radioactively contaminated sites and their remediation and restoration.

At a later stage of its development, the DRCS, even if by no means complete, is expected to provide an overview of the global extent of the problem and the resources required or expended for countermeasures and their respective effectiveness. With regard to radioactive contamination, the IAEA is the only international organization capable, in principle, to provide government and the public concerned worldwide with the relevant, reliable and verified information. Further it is believed that the development process itself would be an important contribution by the IAEA towards a cleaner environment, in line with the stipulations from the Rio conference [1].

On the Member State level, such directories can aid regulatory authorities in assessing the magnitude of risks associated with contaminated sites and can help to prioritize the planning and execution of remedial actions. It is felt that governments cannot efficiently meet their obligations to their people in the field of environmental restoration without the knowledge of the extent and the details of the problem. Such a directory would provide the basic management tool for initiating remediation measures. Relevant steps in management include identification, assessment of potential risks to selected targets and risk-reducing actions, i.e. normally some remediation action.

For those Member States that have not yet defined what constitutes a contaminated site and what should trigger remediation, the DRCS might provide useful examples from other Member States. Further information on radiation safety requirements and relevant guidance may be found in [3].

Another objective of the present technical publication is to provide Member States with an overview of available strategies and methods to identify contaminated sites with the view of developing a directory of such sites on a national or other appropriate administrative level. The technical publication, therefore, discusses types of industries and activities which may have led in some/many cases to contamination (e.g. phosphate industries, metal extraction and production, etc.) Further, the methods to set up such directories will be discussed, e.g. tiered approaches for identification (suspect or potentially contaminated sites).

Such directories may also serve as a vehicle to communicate information to the public, and thus foster public participation.

It is expected that the very process of creating this publication and the DRCS raises further the awareness in Member States concerning potential radiological risk or contamination involving radionuclides arising from non-nuclear activities.

1.3. Scope

Radiologically relevant contamination can arise from a wide variety of nuclear and non-nuclear activities. Some of these activities may require, or may have required, licensing by the relevant authorities in the Member States. In certain instances only part of the operation may fall under relevant radiation protection or waste disposal regulations. However, in all cases poor management or inadequate practices may have resulted in contamination. Accidents are another cause for contamination.

The definition and classification of 'contamination' may vary from country to country, as will be discussed later. For the purpose of this publication a site will be considered as 'contaminated' when radionuclide concentrations exceed background concentrations for anthropogenic reasons to the extent that a possible hazard for the population and the environment needs to be considered.

Not included in the DRCS are sites with currently valid operation or decommissioning licenses. Also outside the scope of the present publication are cases of contamination of the marine environment that are due to the disposal of nuclear wastes or to nuclear weapons testing; these are part of specific inter-agency initiatives at the international level. On the other hand, included are (decommissioned) sites that have been released with restrictions (e.g., requiring institutional control).

2. CLASSIFICATION OF CONTAMINATED SITES

2.1. Definition of contaminated sites

Definitions as to what constitutes a 'contaminated' site vary from Member State to Member State. These definitions tend to be formulated less with scientific rigour in mind, than for administrative, management or legal purposes. For these reasons it is unlikely that international consistency can be reached on the basis of national definitions.

Classification is discussed here, because it provides a convenient means to establish similarities between sites and the origin and effects of their contamination, allowing comparison and conclusions to be drawn. It does also provide a convenient frame for the database structure of the Directory, allowing appropriate querying.

For the purpose of the DRCS, radioactively contaminated sites are broadly defined as those that constitute a part of the natural environment where human activities have introduced man-made nuclides or have enhanced natural radionuclide concentrations above natural background levels to the extent that a possible hazard for the population and the environment needs to be considered [3].

Nevertheless, the DRCS will accept only those sites that have been designated by the responsible Member as being contaminated according to their own definitions and reasoning as will be discussed further down.

2.2. Methods of classification

The rather scientific definition given above would be by itself insufficient for most risk-assessment, administrative, management or legal purposes. In principle classification systems are based on:

(1) the human activity that gave rise to the contamination,

(2) the level of occurrence of a contaminant, e.g. its concentration, or

(3) the effect the contaminant has, or could have, for specified exposure scenario.

Classifications for radiation protection purposes are made on the basis of operational variables, such as the effects resulting from the contamination [3]. Relevant effects could be, for instance, the (estimated) radiation dose received by a critical group.

Based on such classification, the responsible authorities develop an opinion on what would be acceptable in terms of exposure. In most Member States regulations based on such opinions are still under development, or if existing, they differ widely from country to country.

Classification on the basis of specified, generic concentration (or activity) levels for the environmental media or compartments in question appears to be less common in the radiation protection context. Conversely, it is used in most national and international classification schemes for sites contaminated by non-radioactive substances and has the advantage of being exposure scenario independent. Examples for this approach are the so-called Holland-List [4] or the EU Drinking Water Standards [5]. Current approaches are implicitly based on acute human toxicity data, but the issue of chronic low-level exposure and eco-toxicity increasingly finds attention [6][7][8].

In addition to scientific criteria of toxicity, exposure and (radiological) risk, issues of public perception and socio-economic constraints may have been taken into account in developing national systems of classification.

Those Member States that have done so, fixed — for the sake of convenience — generic and site-independent criteria for compliance monitoring, such as maximum permissible concentrations. Since such criteria do not take into account actual or likely exposure, they are frequently over-conservative and, hence, costly to implement.

Contaminated sites can also be classified according to the human activity that gave rise to the contamination. There are two rationales to do so, one is administrative, the other is practical. From an administrative point of view, classification according to activity is useful or even necessary, as different activities might be controlled by different government authorities, or for the purpose of attributing liabilities. From the practical perspective, a given activity leads to typical contamination patterns or predominantly contaminates certain environmental compartments. This knowledge can be used to advantage in the assessment of a site and in remediation planning.

From an administrative perspective, classification according to the type of licensing required at present or at some time in the past would also be a useful option. As licensing requirements have changed over time a historical dimension might need to be introduced.

2.3. Classification according to the type of activity

Sites can be classified according to whether the activity that led to the contamination is currently under nuclear regulatory control or not. Such regulatory control may not only be exercised under civilian jurisdiction [9], but also in the context of defence activities.

(a) Activities under regulatory controls that have established operational limits and conditions in compliance with presently accepted radiation protection principles:

   (i) mining and milling of uranium ores, enrichment and fuel fabrication, nuclear energy production, spent fuel reprocessing, decommissioning of facilities, nuclear weapons production and handling, and radioactive waste management activities;
   (ii) application of ionizing radiation in medicine, research and industry.

(b) Past or present activities outside regulatory control or under regulatory control according to regulations valid in the past, typically including:

   (i) former practices of radioactive waste storage and disposal;
   (ii) production and handling of nuclear weapons and fuel;
   (iii) nuclear tests and other detonations of fissile materials;
   (iv) former practices in nuclear research, including production of isotopes;
   (v) extraction, processing of materials containing natural radionuclides, and other activities that may generate enhanced levels of radionuclides in the terrestrial environment (e.g. extraction of uranium, thorium, rare earths, gas and oil);
   (vi) (industrial) application of radionuclides (e.g. radium for luminescent dials);
   (vii) accidents involving radionuclides if contamination is spread beyond regulated facility and site.

Contamination situations resulting from the activities listed under (a) will not be included into the DRCS, although the same generic criteria may be applied to their characterization. The Directory will focus on situations listed under (b).

It should be pointed out that a valid license does not preclude a site being contaminated in the sense of the definition given in Section 4.1. Some Member States do not classify a site as 'contaminated' when under institutional control. In order to avoid conflicts with national practices and legislation, the restrictions of the preceding paragraph will be applied for setting up the Directory.

Classification according to the type of activity does have a number of operational advantages, in particular with a view to clean-up measures. Similar types of activities tend to create comparable types of problems, and lessons learned and experience gained at one site may be applied to another.

As certain types of industries and activities led to contamination in almost all cases, a worldwide directory of these would help to identify suspect sites, as will be discussed in more detail in Section 5.

2.3.1. *Former practices of radioactive waste storage and disposal*

This category encompasses a large variety of practices, ranging from so-called shallow ground burial of solid waste in trenches without engineered barriers, through sea dumping and discharges of liquid wastes into the marine environment (both not considered in the DRCS), to on-site storage under unsuitable conditions, and to routine underground discharges of liquid waste. In particular, the latter practices may have led — or in the future may lead — to large-scale contamination of soils, surface and groundwaters as a result of uncontrolled dispersion of radionuclides through the environment. Abandoned shallow landfill sites and other waste dumps are susceptible to intrusion and can present a health hazard to humans at some sites.

2.3.2. *Production and handling of nuclear weapons and fuel*

Numerous plants in the United States, United Kingdom, the former Soviet Union and France were producing nuclear materials for defence and commercial purposes from the early stages of the nuclear age on. Other countries, including China, India, Pakistan, Iraq, Israel followed later. Many of these sites have seen a wide spectrum of activities, including extraction and enrichment of uranium, manufacturing of fuel elements and other materials, but also fuel reprocessing. These sites became contaminated as a result of routine releases and numerous leaks and spills from the various chemical processes in the production area. Most contamination is contained within buildings and waste storage areas. The extent of contamination, and the radioactivity associated with it, depends highly on the nature of processes used. While some sites are still in operation, many have now closed down and their license terminated. Where an appropriate legal framework existed and a need was found, such sites have been transferred into a status awaiting restoration. Owing to the size and the complexity of the problem, it has been dealt with only partially.

2.3.3. *Nuclear tests and other detonations of fissile materials*

At present, about 450 atmospheric nuclear tests have been recorded, corresponding to explosions of 545 Mt TNT [10]. Radioactive substances released by these explosions became, in general, global fallout, but high levels of local fallout were observed in some cases. In addition, local contamination also occurred as a result of underground weapons testing.

There is a limited number of nuclear test sites worldwide. In the former Soviet Union atmospheric test explosions have been carried out at Novaya Zemlya and at Semipalatinsk (now in Kazakhstan). Other test sites to be mentioned are: the Nevada Test Site in the USA, Maralinga in Australia, the Bikini (Marshall Islands) and the Mururoa Atolls in the South Pacific, and some others. In addition, more than one hundred nuclear detonations designed to explore their use for civil purposes (creation of artificial caverns, reservoirs and canals) took place in the former Soviet Union, resulting in substantial environmental contamination in some cases.

While detailed information for some nuclear test sites still has not been released, the situation at other sites (Nevada Test Site, Novaya Zemlya, Semipalatinsk, Bikini, Mururoa) has been well described. Radioactive substances released to the surface and sub-surface soil were identified and mapped, and detailed investigations undertaken to plan environmental restoration of these sites.

2.3.4. *Former practices in nuclear research, including production of isotopes*

Some research facilities have performed basic and applied research in high-energy and nuclear physics, material science, nuclear medicine applications and radiobiology since the late 1940s. Many of these programmes were in support of nuclear reactor research and development. Facilities and environmental media became contaminated due to accidental spills and inadequate material management practices.

2.3.5. *Extraction and processing of materials containing natural radionuclides*

Naturally occurring radioactive materials (NORMs) have attracted attention for some time (e.g. [11],[12]), as manufacturing and processing of relevant raw materials can lead to enhanced concentrations and hence increased exposure.

Ores, including uranium ores, are the primary source of relevant radionuclides. In fact many ores not only contain the metal(s) for which they are mined, but frequently (heavy) metals, toxic elements (e.g. arsenic) or organic and inorganic compounds (e.g. cyanides), and other radionuclides at elevated concentrations [13]. The reason is their (geo-)chemical behaviour being similar to the commercial metals. For the same reason, accessory metals are concentrated by the milling process, are subsequently separated and end up, for instance, in the mill-tailings. Disposal facilities for mining and milling residues, both nuclear and non-nuclear related, can lead to exposure scenarios when not properly engineered. Until quite recently this went unnoticed or was ignored. In other instances, mill-tailings and other waste materials from ore processing have been reworked to recover radionuclides or heavy metals of no commercial value previously. Contaminants can be dispersed either through erosion by wind or water, or by leaching.

The phosphates of many metals are only sparingly soluble. Phosphate rock formation, in particular in the marine environment, has led to elevated concentrations of certain heavy metals (e.g. [14]), rare earth elements and radionuclides by (co)-precipitation with these materials. Phosphate rock is mined in large quantities for the production of fertilizers. After processing, the resulting phospho-gypsum tailings contain most of the radioactivity and are either discharged into rivers, land-filled or recycled as a substitute for natural gypsum. If the landfills are re-developed for residential purposes or the gypsum is used for the production of plaster-board, elevated radon concentrations in houses may occur.

Elevated concentrations of NORMs may be also present in oil- and gas-field brines [15]. The sea-bed and its flora and fauna around oil-rigs was found to have elevated levels of radioactivity from discharging brines untreated. Pipe-work and equipment may be contaminated owing to the accumulation of radionuclides in scale [16]. NORMs may be also present in slags, other residues from energy conversion (e.g. fly ash and gypsum from flue gas desulfurication), and building materials (see [12]).

2.3.6. *(Industrial) application of radionuclides*

A number of radionuclides, for instance Ra and Th, have been used in non-nuclear applications. For instance, incandescent mantles for gas-lights have been treated with thorium oxide and radium was the active ingredient in luminescent paint for horological and other instrument applications [17]. For several decades early in the 20th century, radium has also found wide-spread application for medical and pseudo-medical purposes. Several examples of contamination and incidents of radiological relevance are described in the literature. As most of these situations are in urban areas, they require special consideration in the remediation process.

2.3.7. Accidents involving radionuclides

Accidents having wide-spread off-site consequences are primarily those which occurred in the nuclear industry and resulted in the release of large quantities of radioactive materials into the environment. Of the three main incidents, two sites, Kyshtym and Chernobyl [19] [20], are still heavily contaminated at present and large areas remain evacuated. A third site, Windscale [21], has undergone clean-up. The recent incident in Tokaimura, however, has not resulted in any significant off-site contamination [22].

Several accidents involving nuclear weapons [23], have resulted in the environmental dispersion of radioactive materials (including plutonium). To be mentioned here are an explosion and fire in the BOMARC Missile Shelter in the USA (88 ha contaminated), an air-crash over Palomares, Spain (226 ha contaminated), and an air-crash over the ice near Thule, Greenland. In addition, the accident involving the Soviet nuclear submarine *Komsomolets*, which sunk in 1989 to the south-west of and near Bear Island, about 300 nautical miles from the Norwegian coast, might pose potential hazards, though an international expedition performed in 1994 [24] to study among other the ambient radioactivity at the sunken submarine showed that a very limited leakage of Cs and H^3 has occurred from the submarine.

A well-described accident involving a medical source occurred in Goiania, Brazil [25]. Many people incurred large radiation doses due to both external and internal exposure. During remediation of the site, several houses had to be demolished and the contaminated topsoil from the affected areas was removed for safe disposal.

2.4. Classification on the basis of concentration or activity data

A number of conceptual problems arise when defining classes of contamination, and perhaps action levels, on the basis of bulk concentration data. One problem is the bio-availability of the contaminant in question; not all of the contaminant might be relevant. Another problem is the envisaged exposure scenario. The presence of a contaminant in the environment does not necessarily lead to exposure. The former factor is controlled by a range of environmental properties. Exposure scenarios depend on the use of the site. Since these scenarios are difficult to predict for a given site, with some certainty over a longer time-scale, recourse is usually made to some generic and perhaps worst-case scenarios.

In any case, reference has to be made to natural background concentration or activity levels. In certain regions, notably those which have attracted mining, natural background levels may be elevated in comparison to country or world averages. Establishing retrospectively what could have been the natural background level for a given contaminant is by no means trivial and subject of ongoing scientific debate.

As mentioned above, classification criteria derived from concentration or activity assessments are those which stipulate permissible or acceptable levels. These levels are frequently further refined on the basis of very generic land-use scenarios: for instance whether a site is designed to be used for industrial, residential, agricultural or recreational purposes. This inherently defines the degree of clean-up required.

3. DESIGN OF A DIRECTORY

3.1. General considerations

It is obvious that the amount of information that could reside in a directory like this is too vast to be managed efficiently in a centralised way. Continuous updating and maintenance of the information is required to make it a useful tool, which is an expensive undertaking. Experience has shown that attempts to create large and comprehensive databases are prone to failure. There are a number of well recognized reasons for this:

— the data are frequently collated from other databases, the format, structures and contents of which may not be compatible.
— data sources may be subject to frequent updates, which are tedious to follow and implement for the database in question. This may render the database irrelevant for the lack of actuality.
— quality control procedures may be difficult to implement and maintain.

In addition, as these data are the results of costly measuring campaigns, data verification and data collection, and are maintained by various authorities, access to these data and their further use is most likely subject to constraints (copyright, costs). The policy on public access to data also varies from country to country and from institution to institution.

Therefore, a hybrid approach is envisaged, where a meta-database, points towards the original databases on e.g. a national level. This meta-database will contain the results of the questionnaire as a seed for further input and improvements. By developing search facilities (user interface) a 'virtual' directory is created, which points to the most current information by interrogating the source databases. It will provide a summary of the available datasets on which the end user can perform queries.

Creating the search facility constitutes a major task, as it needs to take into account the varying structures of the source databases. The scope of search facilities would be determined by the purpose. Agreeing on the user interface of this meta-database will be the first thing to solve on an international basis. Once the interface is known in detail (this needs to be done in collaboration with all possible end users) the underlying information which is needed to realize it is known, which then defines the conceptual and physical design of the meta-database. In practice, the user interface and the conceptual model of the underlying database are developed in iterative loops, but the draft interface is used in discussions with the customer or end-user. The technical description of the user interface and the physical design of the meta-database provide enough information to a software developer to develop and implement the user interface.

The Internet provides an ideal vehicle for accessing the Directory and in turn to access national databases. Access to the original information can be effected by providing automatic links to the various national databases. However, this has a number of drawbacks:

(1) **administratively:** adding a link will not necessarily (and indeed in many cases it does not) allow access to data of any relevance. In this case it may be subject to a individual requests for access, registration (password), payment, etc.

(2) **technically:** once the end user has access to the national database, he will be constrained to use the query tools as they have been made available by the data provider. Certain problems may arise (e.g. language, codes used) for obtaining the requested information.

To facilitate access to original data in already existing databases, an international data exchange (IDE) format will need to be created. This is needed, as otherwise the end-user will have to continuously convert the format of the dataset being downloaded. Logically the structure of the IDE format will be the lowest common multiple of the available national database structures. In consequence, software will need to be developed to allow conversion from the national to the international format.

3.2. Scope of the directory

The worldwide database, ideally, should provide information relevant to the Member States. The type and level of detail needed for any one country will strongly depend on the character and extent of activities in the nuclear field. For example, in a country with a large nuclear industry where nuclear weapons were manufactured and nuclear tests carried out, the likelihood of radioactive contamination is much larger (and the consequences may be more severe) than in a country performing only extraction and processing of natural minerals.

Conversely, in countries with a developed nuclear infrastructure the management of radioactively contaminated sites may represent a lesser problem than in countries where appropriate infrastructure is less well-developed or even missing. Taking into account the different social, economic and political situations in various countries worldwide, the relative importance of the same piece of information in a national directory may vary from trivial to being essential.

Practical experience, however, shows that the availability of information is often inversely proportional to the extent of past or present activities. Countries with a few and limited activities have a much easier job in reporting than countries such as the USA, the Russian Federation or Germany.

Beyond the scope of the Directory, however, is a discussion of the various techniques available for the characterization of contaminated sites. These techniques encompass a wide range of procedures from screening a potentially contaminated area by airborne or vehicle-borne monitors, through using of hand-held instruments on-site, to taking surface and/or subsurface samples with subsequent detailed laboratory analyses. On this subject, the reader is referred to specialized IAEA publications [26] [27].

The same holds for the actual clean-up operation on contaminated sites. Information on clean-up strategies [28], planning and management [29][30] activities and various clean-up techniques [31][32], and finally the verification of results [33] can be found in other IAEA publications. The assessment of doses potentially incurred by the population, in turn, is discussed in various IAEA publications [34] [35] [3] [36] [37] [38].

Annexes B-1 to B-3 give examples of national registries of contaminated sites in three different Member States.

3.3. Structure of the directory

3.3.1. Principal requirements

While the process of creating a directory of contaminated sites is likely to be educational in itself for most Member States, its value for a future user strongly depends on its format and on the information being current and relevant. A directory should be easily queried. The structure and the mode of its user interface will determine the accessibility of the directory and, hence, its usefulness and acceptance by the targeted end-user group. Therefore a computer-supported, relational database is desirable. For the purpose of spatial analyses a Georeferenced Information System (GIS) would also be a desirable basis.

A range of basic design requirements were formulated, based on both the envisaged use and the anticipated availability of data:

- entry through 'click-able' maps;
- entry through a list of sites sorted according to categories;
- based on GIS or to be portable to such at a later stage of development;
- to contain both meta-data and 'real' data;
- access via the Internet (ideally, or distribution on CD-ROM).

The demand for facilitating access to data not held in-house (meta-data) raises issues such as ownership, confidentiality, access fees etc. (see discussion above). The format of access will eventually determined by the way these problems can be resolved on a case by case basis. The Directory structure will be flexible enough to allow for a wide variety of access levels to meta-data. On the technical level, a generic interface is being provided that can be used at a later stage to devise transposing software for various databases. The design allows for future upgrading, i.e. the structure is modular, making the replacement of functional sections straightforward. The structure also allows for a tiered approach, i.e. data category up-dates are possible, reflecting the improving level of knowledge about a given area and the progress in its characterization.

3.3.2. Data fields and functionalities

A concept for the range of data fields which is required has been developed. Notwithstanding the problem of different approaches and requirements from a national perspective, the DRCS entry will, in general, encompass the following basic information:

- identification and location of the site;
- legal/institutional responsibilities;
- site history;
- site characterization;
- type, levels and extent of contamination;
- potential and actual hazards resulting from site;
- restoration strategies and techniques already applied;
- coordinates to the detailed database.

In addition to merely describing the problem, information on the approach taken towards solution is to be included.

3.3.2.1. Identification of the site

The site will be identified by the name of its owner and/or the name of the community in or near which it is located. The location should be further specified by the state, country (district, province, region). Ideally topographical co-ordinates should also be given.

3.3.2.2. Responsibilities

The responsibilities for making a site safe and for its remediation usually are laid down in the relevant legislation and are determined by various factors, such as the suite of contaminants, the type of ownership and the applicable law. Many countries now have adopted the 'polluter-pays-principle'. However, in the case of former state enterprises, or where polluter has ceased to exist, the situation will be different. In such cases the government may need to assume responsibility in order to protect its citizens.

The Directory should specify the body (natural or legal person, government) responsible for remediation. The responsibility may have been delegated to another body, and in the case of government usually is, such as a contractor or a subsidiary (government) organization. Where the clean-up activities are part of a national remediation programme, listing of legal, organizational and funding aspects may provide useful background information for formulating another country's national policy of contaminated sites management.

Information on funding of remediation works is optional in this context, because cost estimates in absolute terms can vary widely from country to country. Relative differences between labour costs and implementation costs for various techniques may lead to selecting different restoration strategies in the course of the optimization process.

3.3.2.3. History of site contamination

This part should provide a historical description and assessment of activities carried out on the site. The description of the activities should also include information on how the contamination resulted.

3.3.2.4. Site characterization

In order to facilitate preliminary risk assessment and scoping for the applicability of remediation techniques, some information on the geology, hydrology, climatology etc. of the site is desirable.

3.3.2.5. Levels and extent of contamination

The contamination should be specified in terms of specific activities of nuclides in the contaminated media (soil, construction materials, waste rocks, surface or groundwaters, sediments, sludges, landfill materials, etc.). Where appropriate, these data should be complemented with dose measurements on site and compared with natural background radiation levels typical for the area involved. Attention should be given how the contamination should be presented, i.e. as point measurements or as interpolated values (isolines) obtained via a common interpolation procedure from the original measurements or as both.

As regards the extent of contamination, reasonable estimates of the total volume of contaminated media should be given (in cubic meters or metric tons), based on the spatial extent and the likely depth of contamination. Such information is important for a first assessment of the likely countermeasure required. This could be subject of a GIS application.

3.3.2.6. Hazards resulting from contamination and emergency measures taken

The risks and hazards potentially resulting from contamination should be assessed preliminary and at least in qualitative terms. Based on the site characterization data those environmental compartments which are most at risk can be identified. Pertinent demographic data should be collected in order to be able to identify the populations most at risk.

Concluding from the above information, measures to minimize the risk can be suggested; these can range from simple administrative measures, such as prohibiting access, through land use restriction, to the evacuation of local inhabitants in the case of severe contamination.

The problem of transboundary dispersal of contaminants may require special attention, as this poses additional challenges for a coordinated response and equal handling on both sides of the border, in addition to inter-national liability arbitration.

3.3.2.7. Restoration strategy and techniques

Any previous activities aimed at decontamination or remediation of the site and results achieved should be described.

In general, selection of an optimum strategy will depend on a variety of different factors [28]; primarily it should be based on a complex assessment of the specific situation at the site. A detailed description of any risk assessment performed and of the planning for remedial action would be outside the scope of the Directory. For purposes of the Directory, a description of the sequence of clean-up measures together with major milestones will be sufficient. Typically key activities in historical sequence include record screening, field screening, detailed site characterization, planning, stabilization or removal of contaminated material, final site compliance survey, and possibly a long-term monitoring programme, depending on the chosen strategy. A list of techniques to be used during the clean-up operations will provide another valuable information for a potential user facing a similar restoration problem.

3.3.3. Definition of database items and variable values

Taking into account the above topical areas, a consolidated list of database variables was developed. Table I summarises the list of topics and database items. They are given in full in Appendix I. This list is rather comprehensive and it should be pointed out that it is quite unlikely that a comprehensive coverage for all, or even some, site entries can be achieved. However, a comprehensive coverage on the data entry side is likely to remove most of the ambiguities about where to enter a specific information and thus allows for easier comparison of entries.

A hierarchical decimal system has been used to number the data fields and sub-fields. All the data fields are grouped into eight data sections:

Table I. Main database sections

100	IDENTIFICATION AND LOCATION OF THE SITE (AREA)
200	LEGAL/INSTITUTIONAL RESPONSIBILITIES
300	SITE HISTORY
400	SITE CHARACTERIZATION
500	TYPE, LEVELS AND EXTENT OF CONTAMINATION
600	POTENTIAL AND ACTUAL HAZARDS, RESULTING FROM THE SITE AND EMERGENCY MEASURES
700	RESTORATION STRATEGIES AND TECHNIQUES
900	PUBLISHED INFORMATION/DATA ON THE SITE

The sections are divided into sub-sections. For instance, Section 4:

Table II. Sample for sub-sections in database

400	SITE CHARACTERIZATION INCLUDES FIVE SUB-SECTIONS:
410	PHYSICAL GEOGRAPHICAL CHARACTERISTICS
420	GEOLOGICAL AND HYDROLOGICAL CHARACTERISTICS
430	CLIMATOLOGICAL CHARACTERISTICS
450	DEMOGRAPHIC CHARACTERISTICS
460	ECONOMIC DATA

In order to make the structure more flexible, spare numbers of sections (800), sub-sections (for instance, 440, 470, 480, 490, etc.) and fields are provided for.

Many fields are sub-divided into sub-fields. For instance, field "422. Major land cover (non-sealed land) [km^2]" includes six sub-fields:

Table III. Sample for sub-fields in database

422.1.	Forests
422.2.	Grass-land
422.3.	Land under cultivation
422.4.	Gardens
422.5.	Barren/waste land (rocks, sands, etc.)
422.6.	Surface waters/reservoirs

A full list of the database sections, sub-sections and fields is given in Appendix I. For a number of cases explanations and definitions used in names of the sections, sub-sections, fields and sub-fields are needed. Such explanations are given in Appendix II.

The comparability of database entries and, hence, their searchability, depends very much on a uniform description of the database entries throughout the database. Such uniformity can be best achieved by providing the user with a fixed range of choices, rather than allowing free-format descriptions. The range of choice is presented to the user in the form of pull-down menus from which the term most appropriately describing the item at hand is to be selected. The speed of searches and the probility of correct 'hits' is greatly improved by such predetermined lists of variable values. Appendix III gives some tentative examples, based on experience in Germany (see also Annex B-Germany).

A problem to be addressed at a later stage in the development is the language problem. There are two aspects to this problem: While the language of the DRCS as such will be English, other databases refered to or accessed, i.e. meta-data, may be in any of the Member States' languages. It will be technically and logistically relatively difficult to provide acceptable on-line translation, though (semi-)commercial, real-time services are already available. The second aspect is linked to this problem: very often adequate translation of technical terms is not possible.

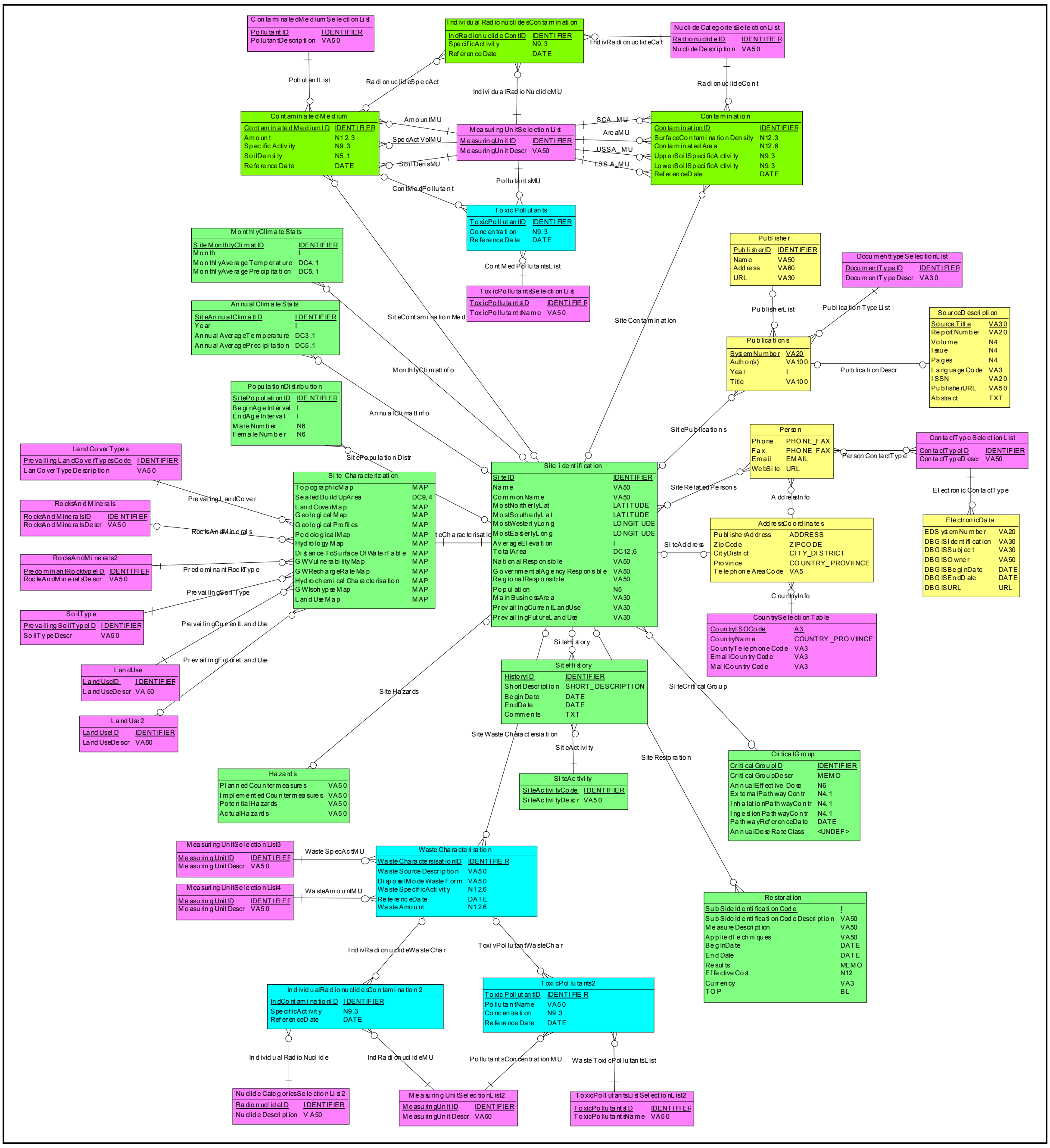

FIG. 1. Conceptual entity relationship diagram of the DRCS.

3.3.4. Conceptual database structure and queries

The DRCS will be implemented as relational database. The basis for the construction of a relational database are the 'conceptual entity relationships' (Fig. 1). These define the interrelations between the various database elements and variables and their respective formats. They also define the criteria and variables by which a database can be queried. Appendix I contains the list of variables and has indicated the ones by which the database can be queried. It is envisaged to group these variables into pull-down menus and to allow to combine queries by boolean operators. The provision of pull-down menus for entering certain variables (see above) will enhance the usability of the search facility.

3.3.5. Identification/geographical referencing of a site

Considering the possible nature and cause of radioactive contamination, the spatial extend of a 'site' can vary from singular spots, a 'site' in the common usage of the word (i.e. an industrial site), to large areas with low levels of contamination straddling several countries, such as resulted from the Chernobyl accident. Given the span of several orders of magnitude, no uniform rules for identifying and referencing a site can be used. The most appropriate method will be determined on a case by case basis, and on the type and the availability of information. Therefore, the database system was designed to be very flexible in this respect. Interfacing with a GIS is foreseen, which from a user's perspective eliminates some of the problem.

Usually geographical co-ordinates (longitude, latitude, elevation) for the common system are given. In the case of larger areas, their maximum extent is to be delineated by the most east and most west longitude, and the highest and lowest latitude respectively, as indicated in the scetch below (Figure 2).

A binary system was also considered, whereby the earth's surface is subdivided into quadrants (see Figure 3), which in turn are divided into quadrants, and so on. It could be useful, in particular for sites of a sizeable extension, but was not implemented in the list of information items (see Appendix I).

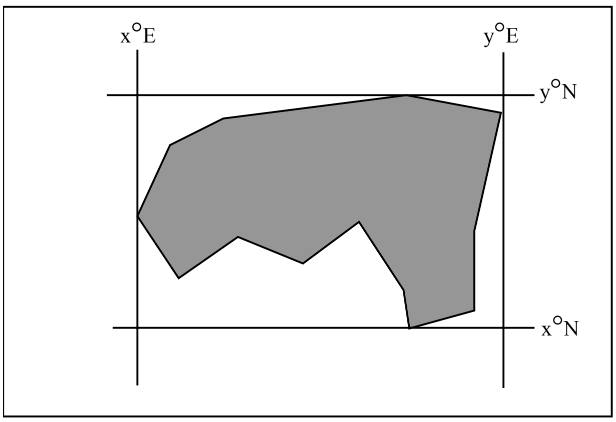

FIG. 2. Delineating the maximum extent of contaminated area by geographical reference coordinates.

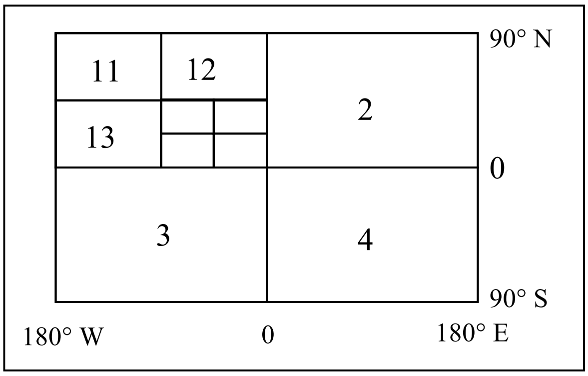

FIG. 3. Location of a site using a system of diminishing quadrants.

3.3.6. Visual data representation

Maps and in particular interactive maps are an efficient way for interaction with the information in a database. Such maps allow users to select points or regions on the map and home in on the data associated with this site or geographical region. Different types of maps will be available: topographic, physical geographical (i.e. land cover, land use, demography), and geological maps, layouts of plants or other hazardous objects, etc. The user can list the maps connected with each other or display the tables, or other kinds of information related to the target of choice.

Depending on the source of the maps and their purpose, some may be interactive, while others are static. While the former would be generated by and during user interaction on the basis of information in the database, the latter represent pre-processed information.

Interactive maps are the prerogative of georeferenced information systems (GISs). A GIS not only serves to present data, but also allows to combine and analyse data according to a variety of (complex) criteria. Interactive map generation includes the plotting of data points according to criteria selected by the users. The user may ask, for instance, questions such as 'Where are the radium-contaminated facilties on a worldwide basis?'.

Static maps may be taken out of existing reports and converted into electronic format, or they may originate from other databases. They will be stored as images in the database, or where applicable, cross-references to their location in other (on-line accessible) databases will be provided. An example for such maps is given in Figure 4 and Appendix IV.

Similar to static maps, with respect to their handling in the database, are (technical) drawings, including geological profiles and cross-sections, and photographic respresentations of contaminated sites or parts thereof. Photographs often can be very informative and provide insight in a very condensed form. Again, drawings and photographs may stored as images, or cross-references ('links') may be provided.

3.3.7. Interfacing with other databases

A modern approach to computer interface design would be based on using the Internet. Using a standard Internet browser, such as Microsoft Internet Explorer™ or Netscape Navigator™, increases the accessibility and eleminates the need to distribute dedicated software packages.

This approach allows the implementation of a single interface for different kinds of data sources in a unified fashion. Thus one can reproduce text reports, tables, maps, diagrams and input forms as pages on the browser. The interface will be common for both the local data access and through the World Wide Web.

Figure 5 shows, using the RADLEG database [39][40] as an example, the interfacing between different data sources, modes of access and output.

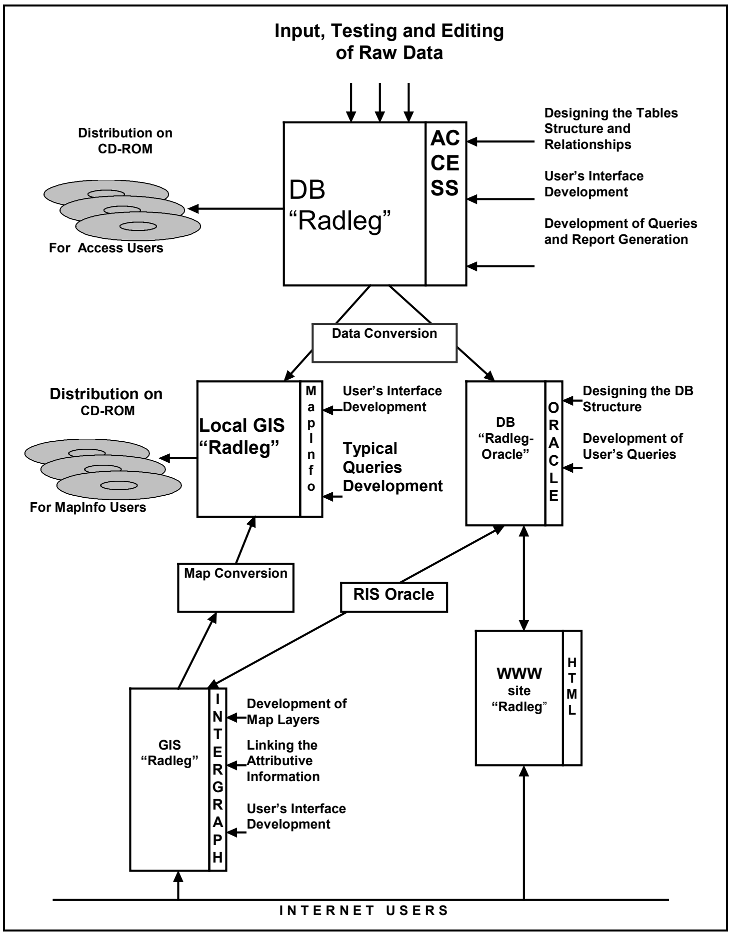

FIG. 4. Schematic layout of the RADLEG database [40] management and interfaces (see also Annex B-4 Russian Federation).

3.4. Prototyping

In addition to the conceptual design, a first prototype "front-end" application was developed. The purpose of the prototype is to test the functionalities defined by the conceptual design. The prototype is platform independent. Therefore, the prototype was developed using HTML to ensure portability between systems. The additional advantage is that no proprietary software will be required for the user to run the database interrogating system.

The prototype front-end was realised as a typical interface for a Windows™ or MacOS™ graphical user interface for the purpose of this TECDOC to exemplify some ot the intended functionalities in the DRCS.

For the implementation of the DRCS prototype, Microsoft Internet Explorer™ was used. The interface is implemented as a set of layers of pages written in HTML. When a user points to a button on the menu or on a 'clickable' part of a map, the program, hides part of the picture on the screen and display in front of it the desired other information (see screenshots in Appendix IV). The windows my be staggered, depending on the type of report selected and the user's requirements. Some windows request additional information that can be input by the user into forms. These are regular HTML-forms that are linked with the server scripts, which in turn are connected to the back-end process mining data into the database. The user may input additional information in HTML-forms to obtain more detailed data. For example, if a user selects the submenu *Histogram* and position *Demography* (see below), he can specify some variables for the presentation of a histogram or a chart. This interface can be linked by scripts or plug-in with the database. In this case maps, charts, histograms will be produced on the fly. This tool can be used, for instance, to provide access to the database on the former USSR radiation legacy [41].

The prototype of the interface should be browsed, using MICROSOFT Internet Explorer 5™ (see Appendix IV for a selection of screenshots).

Two main menus are grouped around the map in the central zone of the application window: one horizontal and one vertical (Figure 6). The user can select any 'box of the menus or point on the map. Thus entry into the database is possible via geographical maps or via the selection of particular functions.

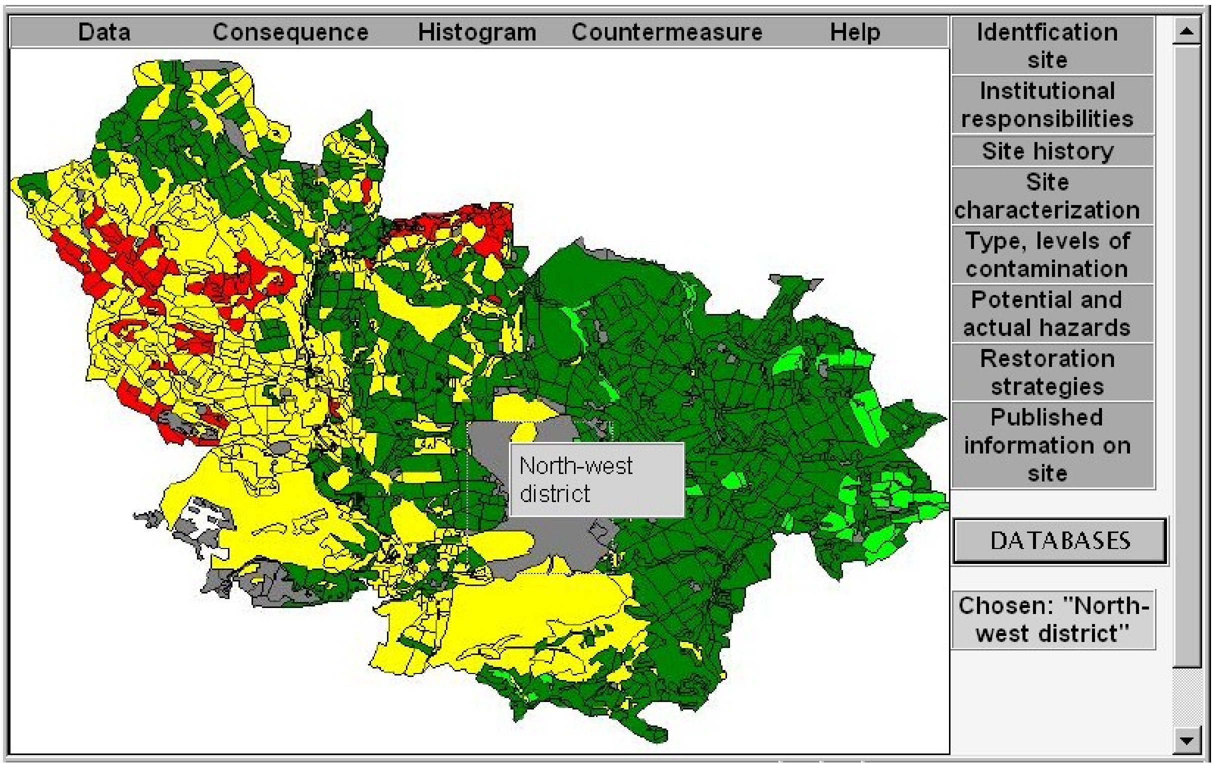

FIG. 5. Screenshot of DRCS prototype user interface.

If a user prefers navigation by menus, he can obtain a set of submenus for each 'box' of the horizontal and vertical menu. The menu allows alternation between maps and reports modes.

— The *Data* submenu can be used to select different map types,
— The *Consequence* submenu can be used for comparing the situation for different moments in time,
— The *Histogram* submenu allows a user to view data as a histograms or diagrams,
— The *Countermeasures* submenu provides information on action taken against the contamination,
— The *Help* submenu describes the system and terms of its usage,
— The vertical menu on the right appears once the user has selected a 'clickable' area on the map. This menu details information on this area, settlement, plant, or other object.

3.5. Provisions for further development

One essential design requirement is modularity, thus allowing improvements to individual functionalities without the need for re-engineering the whole database management tool.

The envisaged purpose and functionality of the DRCS includes becoming a reference tool for users facing similar problems as those described in the database. This may eventually lead to to the development of what is commonly called a "knowledge-based" or "expert" system.

4. DATA MANAGEMENT AND QUALITY CONTROL/QUALITY ASSURANCE (QA/QC)

4.1. General considerations

On the Member State (or designated lower administrative) level, the QA/QC process would start by establishing the Data Quality Objectives (DQOs) before sampling and measurement are performed. DQOs are considered as interactive management tools used to interpret and communicate the data users' needs to the data supplier such as that the supplier can develop the necessary objectives for QA and appropriate levels of QC [28]. In other words: the kind and number of data and their level of detail are to be determined by the user's needs. Therefore the primary QA/QC is a national responsibility, tuned to specific national needs.

However, in the DRCS only data from already existing national sources are considered, and therefore QA on the data the major part of QC processes becomes irrelevant.

QA/QC still has a role in the context of the DRCS, but this role will be mainly limited to identify quality data sources and to guarantee a correct input of data into the meta-database respectively.

While the compiler of a directory often is completely in the hands of his sources as far the reliability of the information as such is concerned, ensuring the correctness of the entries is another objective of quality control procedures. There are various means to assure correctness, such as cross-checking or inter-comparison with other sources, plausibility tests etc., even when the compiler cannot exercise any control on the data source itself. Data can also be checked relatively easily for internal consistency and dimensional correctness, for instance by using automated checking procedures for the various input windows etc. in the user interface. This, in particular, is critical for trans-boundary contaminated areas, where measurements by various independent (national or international) institutes have been performed (e.g. Chernobyl). Comprehensive consistency checks, however would be very time consuming to do in a systematic fashion, so in most cases one has to rely on spot-checks. A number of institutes also keep archives of the sampled material, which in a retrospective way could be used to re-evaluate and inter-compare the original data-sets. Since data are expected to be provided by owners of national databases, QC is best performed at the time when data are entered into the DRCS. Many transcription errors can be avoided by providing pre-set tables (pull-down menus) where the person or the procedure for entering data has to make a selection.

It goes without saying that a complete description of the sampling and measurement techniques used adds value to the data-set description and should be mandatory on a national level; it is an important indicator for the quality of the resulting data and a useful tool when comparing various data-sets amongst each other. Compliance with internationally accepted standards and procedures is also a good indicator for quality, but it does not necessarily assure representativeness of data. In the context of the DRCS, however, this level of detail is expected to be of limited use and probably unobtainable.

Finally, advanced statistics (spatial data analysis) can be employed for evaluating existing data-sets (e.g. by highlighting outliers, spatial correlations between data, etc.) which are indicators for possible uncertainties in sampling/measurements.

The amount and quality of information available on a given contaminated site can be quite variable, depending on the type of contamination, nature and radioactivity of materials involved, the site-specific conditions and its history. Since the acceptance of a database/ directory strongly depends on the actual and perceived reliability of its contents, considerable attention must be given to this point.

4.2. Quality management procedure applied to the DRCS

The quality management of the DRCS has to address three main objectives:

(a) to assure the quality of data entries (QA);

(b) to ensure that data are transcribed correctly from their original sources (QC); and

(c) to ensure that the contents of the database meets the perceived needs of the Member States (overall QA).

Objective (a), that is the QA *sensu strictu*, is addressed by sharing the ultimate responsibility with the Member State concerned. The first step in this consists in identifying the authority that is competent to submit, review and ‘clear’ data on behalf of the Member State. This Authority will have to be nominated by respective country through its Mission to the IAEA. Data may be actually collated from a variety of sources (see below), including official ones from the Member State, but in any case, they are submitted to the Authority for review and clearance. This implies that a distinction is made between the DRCS as a product made available to the public and its underlying database.

The database tool will provide for different levels of access rights and for mirroring the cleared content onto a publicly accessible Web-site (or before imprinting on a CD-ROM to be distributed). That is, the Web-site will designed in a way that prevents access to pages that are used for supplying information unless a valid password is entered. Even then, however, data cannot be entered directly into the database, or changes being made to existing records. Rather, forms are provided, which when completed are submitted to the database administrator. The administrator checks the records for completeness (see Appendix I for mandatory fields) and makes any adjustments necessary to render the information compatible with the requirements for the DRCS. The records are then copied to the Authority for approval before publishing. The data flow and respective access protections is designed such that only cleared information can be copied to the publicly accessible site and in turn that the public can only access cleared information.

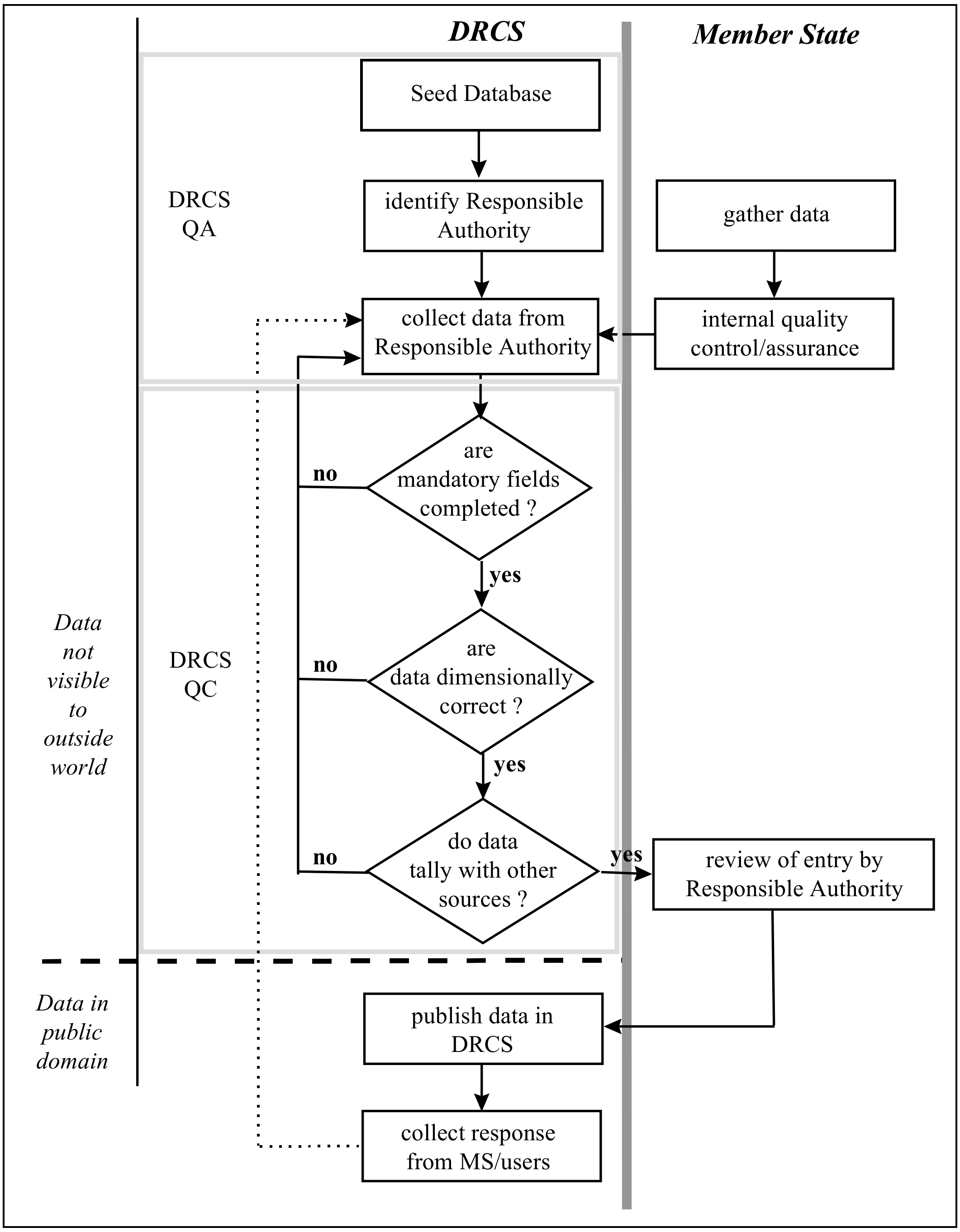

FIG. 6. Flow-chart for DRCS QA/QC management procedure.

Objective (b), that is the quality control procedure, is outlined in its major elements in Figure 7. The Member States' review of the data does not only fulfil the QA requirements, but also serves within the QC procedure to check for transcription or interpretation errors were data have been entered or reformatted by the IAEA. Conversely data entered by Member States will be checked by the IAEA for consistency.

The fact that certain entries may change with time requires that they must be dated and that records must be kept for older entries. Certain items may also require regular checks to ensure their correctness, e.g. references ("URLs") to other databases. Some records will have a separate item 'date' associated with them, where the date to which the information pertains or when measurements have been taken will be recorded. It is obvious that this can become relevant e.g. for short-lived radionuclides with half-lives in the order of less then a few years.

Objective (c). Finally, part of the overall quality management of the DRCS are checks that it meets the requirements of its 'customers'. Useful tools for this purpose are the logging of access to the DRCS and logging of the query profiles used and generated by the users. The database query system thus may be modified in response to the users' needs.

5. DATA ACQUISITION

5.1. General considerations: DRCS vs. national directories

This section describes a selection of possible strategies and mechanisms for data acquisition. Owing to differing data depth and possible primary sources of data these strategies and mechanisms will be somewhat different for the DRCS and directories at the Member State level. Member States may actually have statutory requirements or similar arrangement to provide site information to the competent authority. Where this is not the case, Member States may want to follow some of the strategies outlined below.

The conceptual design for the data acquisition takes into account the QA/QC procedures for the DRCS discussed in Section 4. Thus, data acquisitions proceeds in several steps:

(1) identification of suspect site,

(2) obtaining data/reference to already existing data (meta-data),

(3) confirmation/clearance by competent authority, and

(4) release of data to public domain of DRCS.

5.2. Strategies and methods for site identification

While in some countries well known and even notorious sites exist, in others numerous and more obscure sites may well pose a considerable hazard. These often are not the result of the better documented nuclear activities, but of other industrial undertakings. In order to enlarge the knowledge base, on Member State level it may be therefore of use

- to screen a range of non-nuclear industrial and commercial activities, which are known to be associated with radionuclides;
- to screen historical records with respect to relevant incidents, processes, practices etc., and by analogy with sites having similar historical records and known contamination;

— to share by-products of inspections of sites and facilities
— and to evaluate denunciations or expressions of concern by the public including (environmental) pressure groups.

To be eliminated from this list then are those sites, which are covered by a valid license (see above). The remainder constitute a list of 'suspect' sites, for which more information is to be collected.

5.2.1. Screening of historical records with respect to relevant incidents

Updating and/or supplementing the information on sites already known as being contaminated and perhaps already (partially) characterized in the past may involve similar sources of information. Some countries, e.g. Germany, have developed a tiered approach for collating data and site characterization (c.f. Annex B-1).

5.2.2. Screening of various types of (industrial) activities

Many types of industrial processes result on purpose (e.g. ore processing) or involuntarily in concentrating certain constitutents from natural materials. The CEC CARE project [42] and others [12] identified a range of particularly NORM relevant categories of industries:

— uranium ore exploration, mining, milling and transportation;
— other metal mining and smelting;
— phosphate (fertiliser) industry;
— coal mining and power production from coal;
— oil and gas production[15];
— rare earth and titanium oxide industries;
— zirconium and ceramics industries;
— building materials;
— non-nuclear applications of radium and thorium.

While some of these activities are wide-spread throughout the world, a map of others would indicate possible problem sites. For instance, given the low solubility of many radionuclides under reducing conditions, mining for sulfurous ores and similar might point to potential problems.

An example for a scheme for the classification of contaminated sites on the basis of their use and history is given in Figure 7.

5.2.3. By-product of inspections etc.

First knowledge about the occurrence of contaminated sites may be obtained in various 'unofficial' ways. Such knowledge may become available as by-product of inspections, through denunciation or expressions of concern by the public including (environmental) pressure groups. It is, of course, advisable to confirm such reports independently. As far as the DRCS is concerned, any such information will be submitted to the nominated Authority in the Member States for comments and clearance, as detailed in the section on quality control and assurance.

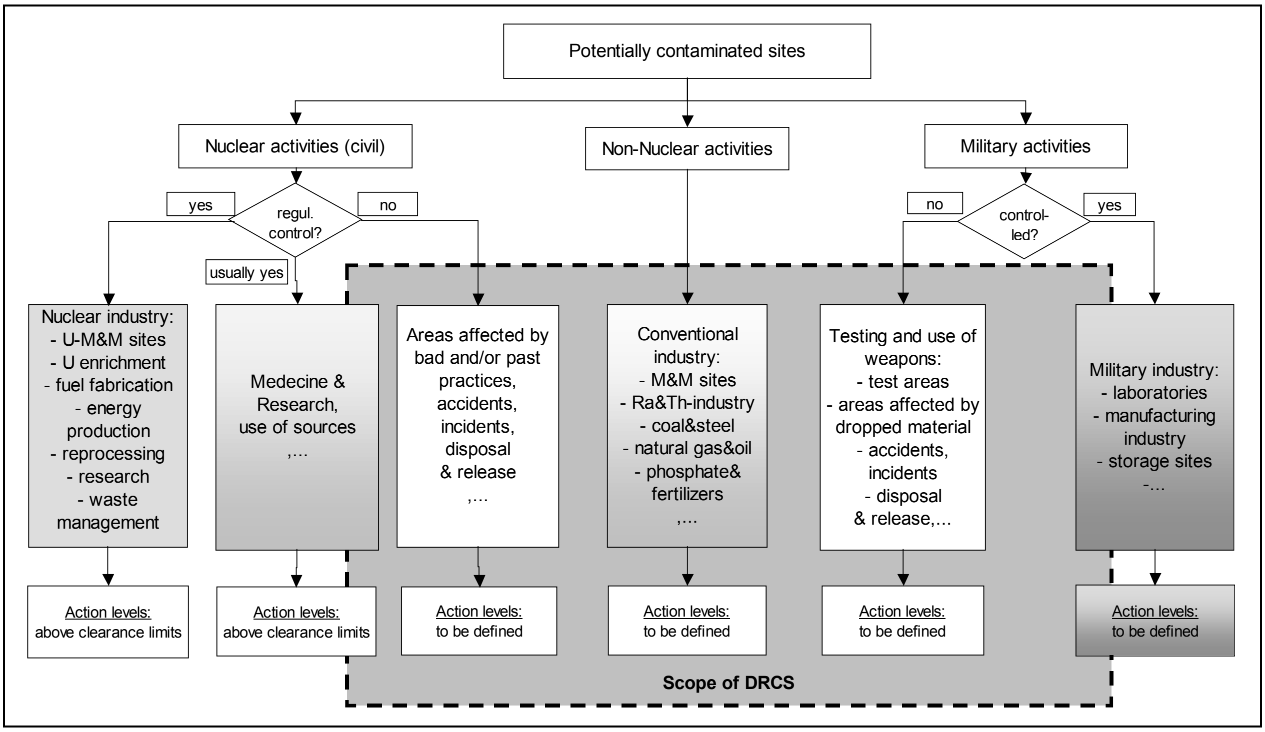

FIG. 7. Possible scheme for the identification and classification of contaminated site.

5.3. Establishing the 'seed' dataset for the DRCS

For the purpose of arriving at a first 'seed' dataset for the DRCS other strategies were employed. These included:

— a questionnaire sent out to the to Member States in 1996;
— sharing of information between relevant IAEA databases, such as the Net-Enabled Waste Management Database (NEWMDB) [43] and the Nuclear Fuel Cycle Information System (NFCIS) [44];
— compilation of data from reports published by other organizations, e.g. the CEC [42]

The database thus established will be submitted to the Member States for review and clearance, as indicated above.

5.3.1. Results of the 1996 questionnaire on contaminated sites

The questionnaire was sent to a total of 123 Member States (Table IV). Thirty-eight Member States responded, of which 24 stated that no radioactive contamination, within the designated scope, were present on their territory. Reports from 14 Member States then provided a spectrum of site characteristics, which was considered a useful starting point for the directory development. A summary of the responses by the Member States is given in Annex A.

Table IV. MEMBER STATES' (AS OF 2001) RESPONSE TO THE QUESTIONNAIRE

Afghanistan	N	Albania	N	Algeria	N	Angola	*
Argentina	N	Armenia	N	Australia	Y	Austria	Y
Bangladesh	N	Belarus	Y	Belgium	N	Benin	*
Bolivia	N	Bosnia and Herzegovina	Y	Brazil	N	Bulgaria	N
Burkina Faso	*	Cambodia	N	Cameroon	N	Canada	N
Chile	N	China	N	Colombia	Y	Costa Rica	N
Cote d'Ivoire	N	Croatia	N	Cuba	N	Cyprus	Y
Czech Republic	Y	Denmark	N	Dominican Republic	N	Ecuador	Y
Egypt	N	El Salvador	N	Estonia	N	Ethiopia	N
Finland	Y	France	Y	Gabon	Y	Georgia	*
Germany	Y	Ghana	N	Greece	Y	Guatemala	N
Haiti	N	Holy See	N	Hungary	Y	Iceland	Y
India	Y	Indonesia	Y	Iran	N	Iraq	N
Ireland	Y	Israel	N	Italy	N	Jamaica	Y
Japan	N	Jordan	N	Kazakhstan	N	Kenya	Y
Korea, Republic of	Y	Kuwait	N	Latvia	*	Lebanon	Y
Liberia	N	Libyan Arab Jamahiriya	N	Liechtenstein	N	Lithuania	Y
Luxembourg	Y	FYR Macedonia	N	Madagascar	N	Malaysia	N
Mali	N	Malta	*	Marshall Islands	N	Mauritius	N
Mexico	Y	Monaco	N	Moldova, Republic of	*	Mongolia	N
Morocco	N	Myanmar	Y	Namibia	N	Netherlands	Y
New Zealand	Y	Nicaragua	N	Niger	N	Nigeria	N
Norway	Y	Pakistan	N	Panama	N	Paraguay	N
Peru	Y	Philippines	Y	Poland	N	Portugal	N
Qatar	N	Romania	N	Russian Federation	N	Saudi Arabia	Y
Senegal	N	Sierra Leone	N	Singapore	N	Slovakia	Y
Slovenia	Y	South Africa	N	Spain	N	Sri Lanka	N
Sudan	N	Sweden	N	Switzerland	Y	Syrian Arab Republic	Y
Tanzania	N	Thailand	N	Tunisia	Y	Turkey	Y
Uganda	N	Ukraine	N	United Arab Emirates		United Kingdom	N
USA	Y	Uruguay	N	Uzbekistan	N	Venezuela	N
Viet Nam	N	Yemen	N	Yugoslavia	N	Zambia	N
Zimbabwe	N						

Notes: Y denotes MS responded, N denotes MS did not return questionnaire;
* denotes that this country has not been an IAEA Member State at the time the questionnaires were distributed.

5.3.2. The Net-Enabled Waste Management Database (NEWMDB)

In recognition that international co-operation is playing an increasingly important role in the development and implementation of national radioactive waste management programmes, the IAEA developed the WMDB [45] [43]. The purpose of the WMDB is to provide a mechanism for the collection, archival and dissemination of information about radioactive waste management in Member States. The WMDB contains information on national waste management programmes, activities, plans, policies, relevant regulations and waste inventories. The information is provided by Member States and is compiled and stored by the IAEA.

The major objectives of the WMDB are to:

— routinely collect information about national, radioactive waste management programmes in Member States and to make this information accessible to all Member States,
— assist the routine review of current and planned IAEA activities through the International Radioactive Waste Technology Advisory Committee (WATAC),

— support the IAEA's International Management Assessment and Technical Review Programme (WATRP), which provides international peer review services, and
— archive information about radioactive waste management activities at the international level.

Data for the WMDB were collected through a series of questionnaires. The latest questionnaire was issued in early 1998 and sought information on the following waste classes: (1) Low and Intermediate Level Waste — Short Lived (LILW-SL); (2) Low and Intermediate Level Waste — Long Lived (LILW-LL); (3) Spent, Sealed Radiation Sources (SRS); (4) Alpha Bearing Waste (TRU); (5) High Level Waste (HLW); (6) Spent Fuel (SF); (7) Decommissioning Waste (DW); and (8) Uranium Mine and Mill Tailings (UMMT).

For UMMT, the following information was requested:

— Responsible organizations and applicable laws, policies and statutes that mandate the organizational responsibilities and activities,
— Regulatory organizations and applicable laws, standards, regulations or codes that have been established or planned to regulate UMMT disposal activities,
— UMMT site(s), location(s), size of each impoundment in hectares,
— Treatment methods for liquid mill effluent that are current or planned,
— Impoundment methods that are current or planned,
— Cover materials in use or planned,
— Seepage control in use or planned,
— Long-term plans for closed out sites,
— Comments on significant milestones and/or events in their national programmes.

It has been decided that the data on UMMT in the future will be held by the DRCS and that the WMDB will be able to access this information.

5.3.3. The Nuclear Fuel Cycle Information System (NFCIS)

The nuclear fuel cycle may be broadly defined as the set of processes and operations needed to manufacture nuclear fuels, to irradiate them in nuclear reactors and to treat and store them, temporarily or permanently, after irradiation. Several nuclear fuel cycles may be considered depending on the type of reactor and the type of fuel used and whether or not the irradiated fuel will be reprocessed.

In 1980, the IAEA began development of the Nuclear Fuel Cycle Information System (NFCIS) [46]. NFCIS is an international directory of civilian nuclear fuel cycle facilities. The purpose of this database is to provide Member States and the IAEA, with current, consistent, and readily accessible information on existing and planned nuclear fuel cycle facilities throughout the world.

The NFCIS contains information on nuclear fuel cycle facilities such as: uranium ore processing, recovery of uranium from phosphoric acid, uranium refining, conversion and enrichment, uranium and mixed-oxide (MOX) fuel fabrication, wet and dry away-from-reactor spent fuel storage, reprocessing, heavy water production, production of Zircaloy and Zircaloy tubing fabrication.

The nuclear fuel cycle information system operates at the International Atomic Energy Agency in its Headquarters in Vienna as a computerised database system since 1985. In January 1998, a major upgrade to NFCIS was completed. The system has been migrated to SQL Server database management system, thus allowing the sharing of information and improving performance in accessing the database. At the end of 1999, a new project started to develop a new service, an Internet site for the Nuclear Fuel Cycle Information System.

Development of this Internet based application has been completed. This Web site [46] allows users from within the IAEA and its Member States to search and retrieve information on nuclear fuel cycle facilities through the international public data networks.

The NFCIS thus provides as set of sites that are potentially relevant. Since for the DRCS only those facilities (or parts thereof) will be considered, where there are no 'licensed' operations at present or which have been marked as 'closed down', the former needs to be ascertained on a case by case basis. Actual entries for the externally available DRCS will be developed from this starting point, if and when data become available.

5.3.4. Data from reports published by other organizations

Several decades of worldwide research and investigations into (radioactively) contaminated areas have generated a vast amount of published and unpublished information. Some countries have made a decisive effort to deal with the legacy of past nuclear activities. To be named here are the US Superfund (inter alia sites contaminated by nuclear R&D and the weapons programme) and UMTRA (uranium mining and milling residues) projects. In 1993 the European Commission organised a conference on radioactively contaminated sites, which brought to light a wealth of information [47].

Another source explored is the RADLEG [41][39] database for the Russian Federation, discussed in more detail in Annex B-Russia.

5.4. Current contents of the prototype DRCS

The contents of the DRCS at present consists of the results of the 1996 questionnaire and the results of a limited literature search. Thus, it should be noted that the content of the database is likely to provide a distorted view as to the relative size of the problem in individual countries. The reason for this is the rather different level of awareness of the problem and the actions taken. In some countries there is high level of awareness and resources are available to take action, or at least to assess individual sites. The response to the questionnaire then has been either comprehensive with many sites listed, leaving the impression that the country has a real problem. On the other hand, the number of sites may have been to numerous to allow a detailed response. Conversely, few entries for a particular country does not necessarily mean that only a few problematic sites exist; the reasons may be simple that others have not been investigated yet.

As has been indicated above, the information available on UMMT sites will be transferred from the WMDB to the DRCS.

6. SUMMARY AND CONCLUSIONS

This technical publication summarises the conceptual design and the preparatory work for creating a worldwide directory of radioactively contaminated sites (DRCS). On the basis of a survey carried out in 1996 and the discussions with experts in the field, it was concluded that an attempt to provide a comprehensive list would be futile. There are a number of reasons for this:

First of all, the actual number of sites to be potentially included is likely to very large and detailed information may not be available for most.

The definition of what constitutes contamination also provides a major obstacle. A part from a scientific definition based on concentration/ activity data, such a definition or classification may be undertaken from an administrative point of view. Here, wider considerations, including socio-economic and political, are taken into account.

For the further development of the DRCS, therefore, a strategy was adopted, whereby only such sites are considered as being ‘contaminated’ that have been officially confirmed by Member States.

The DRCS is intended to be more than just a list of relevant sites. It is intended to contain information on the approaches to deal with the problem, i.e. information on the any associated environmental restoration undertakings. It is hoped that in this way the DRCS can act as a clearing-house for site-specific information on experience with environmental restoration projects.

Owing to the vast amount of data potentially available, any attempt to physically place all the data into a database held at the IAEA was considered impractical. The DRCS, therefore, will be essentially a meta-database, containing a mixture of physically held data and pointers to other data(bases) in the outside world.

For demonstration purposes, a prototype ‘front end’ for the DRCS was developed based on the HTML. Programming in HTML was chosen to make the database accessible via the freely available Internet browsers and to make it accessible through the World Wide Web. Experience exists from some other databases allowing access via the same route (albeit sometimes for registered users only).

The next stages of development foresees the design of an operational database management tool and the establishment of the data quality management structure, including identifying competent contact points in the Member States.

GLOSSARY

* denotes that this definition has been taken (in abbreviated form) from the IAEA Safety Glossary [48].

CEC	Commission of the European Communities
Cleanup*	Any measures that may be carried out to reduce the radiation exposure from existing contamination through actions applied to the contamination itself (the source) or to the exposure pathways to humans. As used in IAEA publications, cleanup has essentially the same meaning as rehabilitation, remediation and restoration.
Contaminated site	In the context of the DRCS a site affected by contamination and recognised as such by the authorities in the respective Member State
Contamination*	Radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the process giving rise to their presence in such places.
DRCS	Directory of Radioactively Contaminated Sites
DW	Decommissioning waste
Exposure*	The act or condition of being subject to irradiation (or chemicals)
HLW	High level waste
HTML	Hyper Text Mark-up Language
Institutional control*	Control of a waste site by an authority or institution designated under the laws of a country. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear facility (e.g. near surface repository).
LILW-LL	Low and intermediate level waste — long lived
LILW-SL	Low and intermediate level waste — short lived
Member State	Member State of the IAEA
Meta-Database	A database providing mainly pointers to and information about other databases
MS	Member State of the IAEA
national	Used here to distinguish from the IAEA, notwithstanding that in a given MS subsidiary administrative levels might be charged with the responsibilities under discussion.
NFCIS	Nuclear Fuel Cycle Information System (http://www-nfcis.iaea.org)
NORM	Naturally occurring radioactive material
QA	Quality assurance — concerned with establishing the procedures to ensure relevant, representative and adequately measured data

QC	Quality control — concerned with ensuring of consistent procedures to meet prestated objectives and quality criteria
Regulatory control*	Any form of control applied to facilities or activities by a regulatory body for reasons related to protection or safety
Restoration*	see cleanup
Remedial action*	Action taken when a specified action level is exceeded, to reduce radiation doses that might otherwise be received, in an intervention situation involving chronic exposure.
Remediation*	see cleanup
SF	Spent fuel
Site	Here a loose term referring to a location that can be identified on an administrative basis, on the basis common usage of denomination etc. The IAEA Safety Glossary implicitly restricts the use to 'site area', i.e. a geographical area that contains an authorized facility, and within which the management of the authorized facility may directly initiate emergency actions.
SRS	Spent, sealed radiation sources
TE-NORM	Technologically enhanced naturally occurring radioactive material
TRU	Alpha-bearing waste
UMMT	Uranium mining and mill tailings
WMDB	Waste Management Database (IAEA)
WWW	World-Wide Web (the Internet)

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Appendix I

DETAILED LIST OF INFORMATION ITEMS IN THE (META-) DATABASE

Ref No.	Description	Format	Mandatory	Query	List
100	**IDENTIFICATION AND LOCATION OF THE SITE (AREA)**				
101	System number	C10	M	Y	
102	Name	C50	M	Y	
103	'Common' name (of site or event with which contamination is associated)	C50	M	Y	
110	**GEOGRAPHIC COORDINATES**				
111	**Latitude**				
111.1	most northerly latitude (in decimal degrees)	N7.4	M	Y	
111.2	most southerly latitude (in decimal degrees)	N7.4	M	Y	
112	**Longitude**				
112.1	most easterly longitude (in decimal degrees)	N8.4	M	Y	
112.2	most westerly longitude (in decimal degrees)	N8.4	M	Y	
113	Average elevation (m)	N4	M	Y	
114	Total area (km^2)	N12.6	M	Y	
120	**LOCATION**				
121	Country	C30	M	Y	Y
122	Province (region)	C30	M	Y	
123	City/district	C50	M	Y	
124	Zipcode	C10	M		
125	Street address	C50	M		
200	**LEGAL/INSTITUTIONAL RESPONSIBILITIES**				
210	**LEGAL FRAMEWORK**				
211	National level	C50			
212	Governmental agency level	C50			
213	Regional level	C50			
220	**OWNERSHIP, OPERATION AND ADMINISTRATION RESPONSIBILITIES**				
221	**Owner(s) of the land**				
221.1	Name	C50	M	Y	
221.2	address	C50	M		
221.3	Zipcode	C10	M		
221.4	City/district	C50	M	Y	
221.5	Province (region)	C30	M	Y	
221.6	Country	C30	M	Y	Y
221.7	Phone	C20			
221.8	Fax	C20			
221.9	E-mail	C30			
221.10	Web-site address	C30			
222	**Operator**				
222.1	Name	C50	M	Y	
222.2	Address	C50	M		
222.3	Zipcode	C10	M		
222.4	City/district	C50	M	Y	
222.5	Province (region)	C30	M	Y	
222.6	Country	C30	M	Y	Y

Ref No.	Description	Format	Mandatory	Query	List
222.7	Phone	C20			
222.8	Fax	C20			
222.9	E-mail	C30			
222.10	Web-site address	C30			

223 **Manager or administrator if different from owner/operator**

223.1	Name	C50		Y	
223.2	Address	C50	M if 223.1		
223.3	Zipcode	C10	M if 223.1		
223.4	City/district	C50	M if 223.1	Y	
223.5	Province (region)	C30	M if 223.1	Y	
223.6	Country	C30	M if 223.1	Y	Y
223.7	Phone	C20			
223.8	Fax	C20			
223.9	E-mail	C30			
223.10	Web-site address	C30			

230 **ADMINISTRATIVE RESPONSIBILITIES FOR THE SITE'S ENVIRONMENTAL REMEDIATION**

231 **Responsible body (national level executive power body or governmental agency)**

231.1	Name	C50	M	Y	
231.2	Address	C50	M		
231.3	Zipcode	C10	M		
231.4	City/district	C50	M	Y	
231.5	Province (region)	C30	M	Y	
231.6	Country	C30	M	Y	Y
231.7	Phone	C20			
231.8	Fax	C20			
231.9	E-mail	C30			
231.10	Web-site address	C30			

232 **Responsible body (regional or local level)**

232.1	Name	C50	M	Y	
232.2	Address	C50	M		
232.3	Zipcode	C10	M		
232.4	City/district	C50	M	Y	
232.5	Province (region)	C30	M	Y	
232.6	Country	C30	M	Y	Y
232.7	Phone	C20			
232.8	Fax	C20			
232.9	E-mail	C30			
232.10	Web-site address	C30			

233 **Responsible body (natural or legal person)**

233.1	Name	C50	M	Y	
233.2	Address	C50	M		
233.3	Zipcode	C10	M		
233.4	City/district	C50	M	Y	
233.5	Province (region)	C30	M	Y	
233.6	Country	C30	M	Y	Y
233.7	Phone	C20			
233.8	Fax	C20			
233.9	E-mail	C30			

Ref No.	Description	Format	Mandatory	Query	List
233.10	Web-site address	C30			
233.11	Status (contractor, subsidiary organization, etc.)	C20	M		Y

240 SOCIAL & ECONOMIC ASPECTS

241	Funding of remediation works	C50		Y	
242	Compensations to affected population	C50			

270 AUTHORIZED CONTACT POINT FOR FURTHER INFORMATION

271.1	Name (entity or person)	C50		Y	
271.2	Street address	C50	M if 271.1		
271.3	Zipcode	C10	M if 271.1		
271.4	City/district	C50	M if 271.1	Y	
271.5	Province (region)	C30	M if 271.1	Y	
271.6	Country	C30	M if 271.1	Y	Y
271.7	Phone	C20			
271.8	Fax	C20			
271.9	E-mail	C30			
271.10	Web-site address	C30			

300 SITE HISTORY

310 TYPE OF ACTIVITY

311 Former disposal practices

311.1	Short description	C50		Y	
311.2	Time period : Begin Date	D	M if 311.1	Y	
311.3	Time period : End date	D	M if 311.1	Y	
311.4	Comments	Memo	M if 311.1		

312 Production of nuclear weapons

312.1	Short description	C50		Y	
312.2	Time period : Begin Date	D	M if 312.1	Y	
312.3	Time period : End date	D	M if 312.1	Y	
312.4	Comments	Memo	M if 312.1		

313 Nuclear tests and other detonations of fissile materials

313.1	Short description	C50		Y	
313.2	Time period : Begin Date	D	M if 313.1	Y	
313.3	Time period : End date	D	M if 313.1	Y	
313.4	Comments	Memo	M if 313.1		

314 Former practices in nuclear research

314.1	Short description	C50		Y	
314.2	Time period : Begin Date	D	M if 314.1	Y	
314.3	Time period : End date	D	M if 314.1	Y	
314.4	Comments	Memo	M if 314.1		

315 Extraction and processing of materials containing natural radionuclides

315.1	Short description	C50		Y	
315.2	Time period : Begin Date	D	M if 315.1	Y	
315.3	Time period : End date	D	M if 315.1	Y	
315.4	Comments	Memo	M if 315.1		

316 (Industrial) application of radionuclides

316.1	Short description	C50		Y	
316.2	Time period : Begin Date	D	M if 316.1	Y	
316.3	Time period : End date	D	M if 316.1	Y	
316.4	Comments	Memo	M if 316.1		

Ref No.	Description	Format	Mandatory	Query	List
317	**Accidents involving radionuclides**				
317.1	Short description	C50		Y	
317.2	Time period : Begin Date	D	M if 316.1	Y	
317.3	Time period : End date	D	M if 316.1	Y	
317.4	Comments	Memo	M if 316.1		
400	**SITE CHARACTERIZATION**				
410	**PHYSICAL GEOGRAPHICAL CHARACTERISTICS**				
412	Topographical map	map			
420	**LAND COVER**				
421	Sealed/built-up area [km^2]	N9.4			
422	prevailing land cover	C30	M	Y	Y
423	Land-cover map	map			
430	**GEOLOGICAL AND HYDROLOGICAL CHARACTERISTICS**				
431	**Geology**				
431.1	Geological map	map			
431.2	Geological profile(s)	?			
431.4	Predominant rock type	C30	M	Y	Y
432	**Pedology**				
432.1	Prevailing soil type	C30	M	Y	Y
432.2	Pedological map	map			
434	**Surface water hydrology**				
434.1	Hydrology map	map			
435	**Groundwater**				
435.1	GW isohypse map	map			
435.2	Distance to surface of water table	map			
435.3	GW vulnerability map (distribution of permeable/impermeable covers)	map			
435.4	GW recharge rate map	map			
435.5	Hydrochemical characterisation / quality data	?			
435.6	Permeability distribution	map			
440	**CLIMATOLOGICAL CHARACTERISTICS**				
442	**Temperature**				
442.1	**Annual statistics**	***this section***	***can be***	***repeated***	
442.1.1	Year	N4			
442.1.2	Annual average temperature (°C)	N3.1			
442.2	**monthly statistics**	***this section***	***can be***	***repeated***	
442.2.1	Month	N2			
442.2.2	Monthly average temperature (°C)	N4.1			
444	**Precipitation**				
444.1	**Annual statistics**	***this section***	***can be***	***repeated***	
444.1.1	Year	N4			
444.1.2	Annual average amount of precipitation (mm)	N5.1			
444.2	**Monthly statistics**	***this section***	***can be***	***repeated***	
444.2.1	Month number	N2			
444.2.2	Monthly average amount of precipitation (mm)	N5.1			

Ref No.	Description	Format	Mandatory	Query	List
444.3	Isopleth maps	map			
450	**DEMOGRAPHIC DATA**				
451	Population in area actually/potentially affected by contamination [x 1000]	N5			
452	**The population age/sex distribution ratio**	***this section***	***can be***	***repeated***	
452.1	Begin interval age (years)	N2			
452.2	End interval age (years)	N2			
452.3	Number of male habitants	N6			
452.4	Number of female habitants	N6			
453	Description of critical group	Memo			
460	**ECONOMIC DATA**				
461	Main business areas (e.g. agricultural, industrial, service, etc.)	C30			Y
463	**Current land use [%]**				
463.1	Prevailing current land use	C30	M	Y	Y
463.2	Land-use map	map			
464	**Future (planned) land-use (limited to the site)**				
464.1	Prevailing future land use	C30	M	Y	Y
500	**TYPE, LEVELS AND EXTENT OF CONTAMINATION**				
501	External gamma dose-rate level [nSv/h]	N6			
510	**RADIOLOGICAL CONTAMINATION LEVEL**				
511	**Radioactive contamination of lands, total activity**				
511.1	Surface contamination density	N12.3			
511.2	Measuring unit for 511.1	C10	M if 511.1		Y
511.3	Contaminated area [km^2]	N12.6			
511.4	Mean specific activity level in soil, depth 0-15 cm (e.g. Bq/m^2)	N9.3			
511.5	Measuring unit for 511.4	C10	M if 511.4		Y
511.6	Mean specific activity level in soil, depth below 15 cm (e.g. Bq/m^2)	N9.3			
511.7	Measuring unit for 511.6	C10	M if 511.6		Y
511.8	Reference date	D	M if 511.1		
512	**Radioactive contamination of lands, individual radionuclides**	***this section***	***can be***	***repeated***	
512.1	Radionuclide	C15		Y	Y
512.2	Surface contamination density	N12.3			
512.3	Measuring unit for 512.2	C10	M if 512.2		Y
512.4	Contaminated area [km^2]	N12.6			
512.5	Mean specific activity level in soil, depth 0-15 cm	N9.3			
512.6	Measuring unit for 512.5	C10	M if 512.5		Y
512.7	Mean specific activity level in soil, depth below 15 cm	N9.3			
512.8	Measuring unit for 512.7	C10	M if 512.7		Y
512.9	soil sample density (kg/m^3)	N5.1	M if 512.1		
512.10	Reference date	D	M if 512.1		
514	**Total dose to critical group**				
514.1	Annual effective dose (μSv)	N6			
514.2	**Pathway contribution to dose [in % of total]**				
514.2.1	External [%]	N4.1			
514.2.2	Inhalation [%]	N4.1			

Ref No.	Description	Format	Mandatory	Query	List
514.2.3	Ingestion [%]	N4.1			
514.3	Annual dose range class No. (cf. IAEA TECDOC-987)	?			
514.4	Reference date	D	M if 514.2		

520 CONTAMINATED ENVIRONMENTAL MEDIA CHARACTERIZATION

521 Contaminated medium *this section can be repeated*

Ref No.	Description	Format	Mandatory	Query	List
521.1	Type of the contaminated medium	C50			Y
521.2	Amount (volume)	N12.3			
521.3	Measuring unit for 521.2	C10	M if 521.2		Y
521.4	Specific (volume) activity level	N9.3			
521.5	Measuring unit for 521.4	C10	M if 521.4		Y
521.6	Soil/sample density	N5.1	M if 521.1		
521.7	Reference date	D	M if 521.1		
521.8	**Individual radionuclides in the contaminated medium**	*this section*	*can be*	*repeated*	
521.8.1	Name of radionuclide	C15			Y
521.8.2	Specific activity	N9.3	M if 521.8.1		
521.8.3	Measuring unit for 521.6.2	C10	M if 521.8.1		Y
521.8.4	Reference date	D	M if 521.8.1		
521.9	**Toxic pollutants in the contaminated medium**	*this section*	*can be*	*repeated*	
521.9.1	Name of pollutant	C50			Y
521.9.2	Concentration	N9.3	M if 521.9.1		
521.9.3	Measuring unit for 521.7.2	C10	M if 521.9.1		Y
521.9.4	Reference date	D	M if 521.9.1		

540 RADIOACTIVE AND HAZARDOUS WASTE CHARACTERIZATION (for former waste disposal facilities only)

541 Waste type *this section can be repeated*

Ref No.	Description	Format	Mandatory	Query	List
541.1	Waste source description	C50			
541.2	Mode of disposal/waste form	C50			Y?
541.3	**Waste specific (volume) activity**				
541.3.1	Waste specific (volume) activity level	N12.6			
541.3.2	Measuring unit for 541.3.1	C10	M if 541.3.1		Y
541.3.3	Reference date	D	M if 541.3.1		
541.4	**Waste amount**				
541.4.1	Waste amount (volume)	N12.6			
541.4.2	Measuring unit for 541.4.1	C10	M if 541.4.1		Y
541.5	**Individual radionuclides in the waste**	*this section*	*can be*	*repeated*	
541.5.1	Name radionuclide	C15			
541.5.2	Specific (volume) activity	N12.6	M if 541.5.1		
541.5.3	Measuring unit for 541.5.2	C10	M if 541.5.1		Y
541.5.4	Reference date	D	M if 541.5.1		
541.6	**Toxic pollutants in the waste**	*this section*	*can be*	*repeated*	
541.6.1	Name pollutant	C30			
541.6.2	Concentration	N12.6	M if 541.6.1		
541.6.3	Measuring unit for 541.6.2	C10	M if 541.6.1		Y
541.6.4	Reference date	D	M if 541.6.1		

Ref No.	Description	Format	Mandatory	Query	List
600	**POTENTIAL AND ACTUAL HAZARDS ISSUING FROM THE SITE AND EMERGENCY MEASURES**				
610	ACTUAL HAZARDS	C50	M	Y	Y?
620	POTENTIAL HAZARDS	C50	M	Y	Y?
630	**HAZARD MINIMIZATION MEASURES**				
631	Implemented countermeasures	C50	M	Y	Y?
632	Planned countermeasures (scenarios)	C50	M	Y	Y?
700	**RESTORATION STRATEGIES AND TECHNIQUES**				
710	**RESTORATION MEASURES TAKEN**				
711	Identification of sub-site to which measure is applied	C50			
712	**List of measures taken and techniques applied**	***this section***	***can be***	***repeated***	
712.1	Measure description	C50	M if 711	Y	Y?
712.2	Technique(s) applied	C50	M if 711	Y	Y?
712.3	Begin time period	D	M if 712.1		
712.4	End time period	D	M if 712.3		
712.5	Results of the taken measure	Memo			
712.6	Effective cost	N12	M if 712.1		
712.7	Currency	C3	M if 712.5		Y?
730	**RESTORATION MEASURES PLANNED**				
731	Identification of sub-site to which measure is applied	C50			
732	**List of planned measures and techniques to be applied**	***this section***	***can be***	***repeated***	
732.1	Measure description	C50	M if 731	Y	Y?
732.2	Technique(s) to be applied	C50	M if 731	Y	Y?
732.3	Begin time period	D	M if 732.1		
732.4	End time period	D	M if 732.3		
732.5	Results anticipated	Memo			
732.6	Cost estimate	N12	M if 732.1		
732.7	Currency	C3	M if 732.5		Y
900	**PUBLISHED INFORMATION/DATA ON THE SITE**				
910	**PUBLISHED PROFESSIONAL COMMUNICATIONS**				
911	System number	C20			
912	Author(s)	C100	M if 911	Y	
913	Year of publication	N4	M if 911	Y	
914	Title, subtitle	C100	M if 911	Y	
915	Document type (journal article, conference paper, monograph, technical report, brochure, etc.)	C30	M if 911	Y	Y
916	**Source description**				
916.1	Source title (journal, series, conference proceedings, etc.)	C30		Y	
916.2	Report index/number	C20	M if 916.1	Y	
916.3	Volume	N4	M if 916.1		
916.4	Issue	N4	M if 916.1		
916.5	Page numbers	N4	M if 916.1		
916.6	Language	C20	M if 916.1		Y
916.7	ISSN	C20	M if 916.1	Y	
916.8	URL (if published electronically)	C30			

917 Publisher

917.1	Name	C50		Y	
917.2	Location (country, city)	C50	M if 917.1		
917.3	Web-site address	C30			

919	Abstract	Memo			

920 ELECTRONIC DATA SOURCES

921	System number	C20			
922	Database (GIS) identification	?			
923	Database (GIS) subject	?			
924	Database (GIS) owner	?			
925	Time period which the data concern: begin date	D			
926	Time period which the data concern: end date	D			
927	Web-site address	C30			

928 Contact information/database administrator

928.1	Country	C30			Y
928.2	Province (region)	C30			
928.3	City/district	C30			
928.4	Street address	C50			
928.5	Phone	C20			
928.6	Fax	C20			
928.7	E-mail	C30			
928.8	Web-site address	C30			

930 MASS-MEDIA PUBLICATIONS

931	System number	C30			
932	Author(s)	C100			
933	Date of publication	D			
934	Title, subtitle of publication	C100			
935	Type of mass-media organ (monthly or weekly magazine, daily or weekly newspaper, TV-program, etc.)	C30			Y

936 Source description

936.1	Title of mass-media organ	C30			
936.2	Issue number	N4			
936.3	Page number(s)	N4			
936.4	URL (if published electronically)	C30			
936.5	Language	C20			

937	Publishing location (country, city)	C50			
938	Abstract	Memo			

Appendix II

DESCRIPTION OF AND COMMENTS ON DATABASE FIELDS

100. IDENTIFICATION AND LOCATION OF THE SITE (AREA)

101. System number

The unique number of an entry in the meta-database and to be given by the DRCS administration.

102. Name

It may be the name of the site's owner and/or the name of the entity or the community near which it is located. For instance: *102. Gorodskoi Island*

103. «Common» name

(of site or event with which the contamination is associated), if there is any.

110. GEOGRAPHIC COORDINATES

111. Latitude and **112. Longitude**

are filled in, for instance as *111. 58, 25° North* and *112. 83.76° East* , if a site's size is so, that the values of difference between the highest and the lowest values of the latitude and between the most east and the most west values of the longitude are less than a hundredth of a degree. Otherwise the sub-fields 111.1, 111.2 and 112.1, 112.2 are filled in. This sub-fields give the highest and lowest latitude of the extent of the contaminated sites, and the East- and West-most extent respectively (cf. Fig. X).

120. LOCATION

121. Country

Country's two-symbol code is to be given, according to corresponding INIS guidelines. For instance: *121. US*

122. province/region

For instance: *122. Ohio*

122. city/district

For instance: *123. Fernald*

200. LEGAL/INSTITUTIONAL RESPONSIBILITIES

210. LEGAL FRAMEWORK

References to legislative acts and normative/regulatory documents related to issues of a contaminated site's management are given. For instance:

211. Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 (US Public Law 95-604)

212. Uranium Mill Tailings Remedial Action (UMTRA) Project of the UD Department of Energy

213. On Measures for Implementation of the RF Law of May 20, 1993 «On the Social Protection of Citizens Affected by Radiation as a Result of the 1957 Accident at the IndustrialAssociation «Mayak» and Disposal of Radioactive Waste into the Techa River» (Decree of the Head of Administration of the Chelyabinsk Region of March 02, 1994)

220. OWNERSHIP, OPERATION AND ADMINISTRATIVE RESPONSIBILITIES

221. Owner (s) of the land

For instance: 221.1. Government of the Russian Federation
221.2. 2 Krasnopresnenskaya Naberezhnaya,
103 274 Moscow, Russia

222. **Owner (s) of operations**

For instance: 222.1. Joint-Stock Society «Machine-Building Plant»
222.2. 144 000, PB 98, Elektrostal, Moscow Region, Russia

230. **RESPONSIBILITIES FOR THE SITE'S ENVIRONMENTASL REMEDIATION**

231. **Responsible body (national level executive power body or governmental agency)**

For instance: 231.1. Ministry on Atomic Energy of the Russian Federation
231.2. 26 Bol'shaya Ordynka Ulitsa, 101 000 Moscow, Russia

240. **SOCIAL & ECONOMIC ASPECTS**

241. **Funding of remediation works**

Information is to be given on sources of funding of the remediation work, the allotted sums and the work schedules

242. **Compensations to the population**

Forms and the order of compensations to population affected by the radioactive contamination are to be given.

300. **SITE HISTORY**

310. **TYPE OF ACTIVITY**

This sub-section includes six fields related to different types of activities led to radioactive contamination of sites. New fields can be added, if necessary. Each field includes two sub-fields. In the first one time period (or a date) of events led to the radioactive contamination is indicated. The second (Comments) is narrative and provides a historical description and assessment of activities carried out on the site. The description of the activities should also include information on how the contamination resulted.

400. **SITE CHARACTERIZATION**

Fields 401, 402, 411, 413 are numerical.

412 and 421 are respectively a site's clickable topographical and geological maps are presented.

422 to **425** are narrative.

431 gives names and addresses of relevant meteorological stations.

432 gives the frequency distribution of winds at the site is presented in the form of a table. An example of such a table is given below (see Table II-1).

450. **DEMOGRAPHIC DATA**

In this sub-section numerical information is presented necessary for population dose evaluation and making assessment of applicability of remediation measures.

451 **Population number in a zone potentially affected by the site's radioactive contamination**

In each case a decision, concerning limits of such a zone will be arbitrary and will depend either on national regulation standards or local attitudes. It may be a 30 km zone around a certain object or a territory of a certain administrative unit (province, land, district, county, etc.).

452 and **453** data concerning population sex/age structure of such a zone and the inhabitants' typical ration characteristics, are presented.

460. **ECONOMIC DATA**

Fields 462 and 463 are numerical, fields 461 and 464 are narrative.

Table II-I. Frequency of winds and calms (%) and mean values of wind velocities V [m/s] in a central part of the site

	N		N E		E		S E		S		S W		W		N W		Ca lm	
Month	%	V	%	V	%	V	%	V	%	V	%	V	%	V	%	V	%	V
January	7.4	2.4	3.3	2.0	8.5	2.7	14.4	3.1	16.6	3.2	15.5	3.2	22.5	3.9	11.8	3.6	8.8	0.0
February	6.6	3.3	5.7	2.5	12.8	3.1	18.7	3.8	14.8	3.2	11.4	3.1	18.0	3.6	12.2	3.2	8.7	0.0
March	6.2	2.8	6.0	3.3	12.4	2.9	18.2	3.3	17.0	3.3	13.5	3.3	17.4	3.7	9.2	3.3	7.6	0.0
April	10.9	3.2	7.5	2.8	13	2.7	16.3	3.4	13.6	3.3	10.4	3.2	15.7	3.4	2.5	3.3	7.9	0.0
May	13.4	2.8	8.2	2.5	14.2	2.7	15.7	3.0	15.5	3.2	7.4	2.6	13.5	2.7	12.0	2.9	13.3	0.0
June	17.2	2.5	6.8	2.5	8.8	2.3	9.7	2.6	12.0	2.7	9.6	2.6	20.7	2.8	15.2	3.0	16.9	0.0
July	16.4	2.7	6.6	2.2	7.6	2.1	6.9	2.3	11.6	2.6	9.8	2.5	23.6	2.6	17.6	2.7	20.1	0.0
August	16	2.4	6.0	2.2	8.0	2.0	10.3	2.3	16.0	2.6	9.4	2.5	20.6	2.6	13.6	2.5	21.3	0.0
September	10.7	2.4	4.2	1.9	6.9	2.3	12.2	2.8	16.8	2.9	2.8	2.7	25.1	2.7	11.3	2.9	13.6	0.0
October	6.2	2.5	2.9	2.3	9.3	2.4	14.0	3.1	19.1	3.0	4.7	2.9	22.6	3.1	11.1	2.9	10.6	0.0
November	5.2	2.4	3.0	2.1	8.3	2.6	17.7	3.8	17.4	3.1	6.0	3.1	22.6	3.6	1.0	3.6	7.5	0.0
December	6.2	2.7	4.1	2.3	7.2	2.4	12.5	3.1	17.7	3.1	6.5	3.1	23.0	3.5	2.8	3.3	7.0	0.0
Winter	6.7	2.8	4.4	2.3	9.5	2.7	15.2	3.3	16.4	3.2	14.5	3.1	21.2	3.7	12.3	3.4	8.2	0.0
Spring	10.2	2.9	7.2	2.8	13.2	2.8	16.7	3.2	15.3	3.3	10.5	3.0	15.5	3.2	11.3	3.2	9.6	0.0
Summer	16.6	2.5	6.5	2.3	8.1	2.1	9.0	2.4	13.2	2.6	9.6	2.5	21.6	2.6	15.5	2.7	19.4	0.0
Autumn	7.4	2.4	3.4	2.1	8.2	2.4	14.6	3.2	17.8	3.0	14.5	2.9	23.4	3.2	10.8	3.1	10.6	0.0
Warm season	12.1	2.7	6.0	2.4	10.0	2.4	12.9	2.9	15.2	2.9	11.0	2.8	19.9	2.9	12.8	2.9	13.9	0.0
Cold season	6.3	2.7	4.0	2.2	9.2	2.7	15.8	3.4	16.6	3.2	14.8	3.1	21.5	3.7	11.7	3.4	8.0	0.0
Annual	10.2	2.7	5.4	2.4	9.7	2.5	13.9	3.0	15.7	3.0	12.3	2.9	20.4	3.2	12.5	3.1	11.9	0.0

500. TYPE, LEVELS AND EXTENT OF CONTAMINATION

Numerical data are presented in the fields 501, 511, 512. For example:

501. *10 μR/h*
511.1. *$6*10^3$ Bq/m^2*
511.2. *0.150 km^2*
511.2. *680 Bq/kg*
511.4. *82 Bq/kg*
512.1.1. *^{137}Cs*
512.1.2. *$4*10^3$ Bq/m^2*
512.1.3. *0.150 km^2*
512.1.4. *390 Bq/kg*
512.1.5. *55 Bq/kg*
512.2.1. *^{90}Sr*
512.2.2. *$1.1*10^3$ Bq/m^2*
512.2.3. *0.150 km^2*
512.2.4. *160 Bq/kg*
512.2.5. *25 Bq/kg*

514. Dose rate level

The field includes three sub-fields:

514.1. Pathway contribution to dose, %

An example of filling the sub-field:

514.1.1. External**:** 2.7
514.1.2. Inhalation: 94.5
514.1.3. Ingestion: 2.8

514.2 Annual dose range class

Annual dose range class is indicated in accordance with classification according to IAEA-TECDOC-987 (see Table AII-II).

Table AII-II. Classification of contaminated sites according to dose rates and resulting clean-up requirements

Class No.	Annual dose range	Is clean-up needed?
Class 6	>100 mSv/a	always
Class 5	10–100 mSv/a	almost always
Class 4	1–10 mSv/a	almost always/usually
Class 3	0.1–1 mSv/a	usually/sometimes
Class 2	10–100 μSv/a	rarely
Class 1	<10 μSv/a	almost never

514.3. **Reference date**

Reference date is indicated. For instance: *1996-06-15*

520. **CONTAMINATED ENVIRONMENTAL MEDIA CHARACTERIZATION**

In this sub-section data, concerning various contaminated media on the site are presented. Each of the field Nos. from 521 to 539 relates to an individual medium (cross-references with the geographical and geological data are envisaged). For instance:

5.2.1 *Groundwater*
521.1. *Liquid*
521.2. $600*10^3\ m^3$
521.3. $4.5*10^4\ Bq/m^3$
521.4.1.1. ^{137}Cs
521.4.1.2. $3.6*10^4\ Bq/m^3$
521.4.2.1. ^{90}Sr
521.4.2.2. $0.7*10^4\ Bq/m^3$
...
521.5.1.1. *Mercury*
521.5.2. $0.2\ g/m^3$
...
521.6. *1996-06-15*
522. *Bottom sediments*
522.1. *Solid*
522.2. $150*10^3\ t$
522.3. $6.0*10^5\ Bq/kg$
522.4.1.1. ^{137}Cs
522.4.1.2. $4.4*10^5\ Bq/kg$
522.4.2.1. ^{239}Pu
522.4.2.1. $0.6*10^5\ Bq/kg$
...
522.4.1.1. *Mercury*
522.5.1.2. *0.05 g/kg*
...
522.6. *1996-06-15*

540 **RADIOACTIVE AND HAZARDOUS WASTE CHARACTERIZATION**

In this section data are presented for former waste disposal facilities only. Each of the fields Nos. from 541 to 549 relate to an individual kind of liquid radioactive/hazardous waste. Each of the fields Nos. from 551 to 559 relate to an individual kind of solid radioactive/hazardous waste. For instance:

541. *Liquid (aqueous) radioactive waste*
541.1. *From radiochemical liquid-extraction plutonium separation process*
541.2. *Surface type storage facility. Loamy isolation layer on bottom and slopes with 1 m thick soil layer above loamy shield.*
541.3. $2.3*10^{12}$ *Bq/m*^{3}
541.4. $1.9*10^5$ *m*^{3}
541.5.1.1 ^{137}Cs
541.5.1.2. $1.1*10^{12}$ *Bq/m*^{3}
...
541.5.4.1 ^{106}Ru
541.5.4.2. $0.5*10^{11}$ *Bq/m*^{3}
...
541.6.1.1. *Tributyl phosphate*
541.6.2.2. *0.2 g/m*^{3}
...
541.7. *1998-05-25*
...
552. *Solid radioactive waste*
552.1. *From* UF_6 *production plant*
552.2. *Earthen trench-type burial without damp-proofing of bottom and slopes. Vertical leveling with soil on waste top has been carried out*
552.3. $0.4*10^6$ *Bq/kg*
552.4. $4.2*10^3$ *t*
552.5.1.1. ^{238}U
552.5.1.2. $0.35*10^6$ *Bq/kg*
552.5.2.1. ^{234}U
552.5.1.2. $0.03*10^6$ *Bq/kg*
...
552.7. *1997-08-10*

600. POTENTIAL AND ACTUAL HAZARDS ISSUING FROM THE SITE AND EMERGENCY MEASURES

The section contains narrative information. The actual hazards (sub-section 610) and risks, potentially resulting from a site's contamination (sub-section 620) should be assessed at least in qualitative terms. Environmental compartments, which are most at risk can be identified, basing on the site characterization data. Reference to demographic data can be made in order to identify the population groups most at risk. For instance:

610. *Risks of fires and radionuclide migration in soil and ground-waters. Groups of the site inhabitants, consuming milk and vegetables produced at the contaminated lands are most at risk.*

620. *Risks to population, living outside the site, but consuming agricultural products from the contaminated lands.*

Concluding from the above information measures to minimize the risk can be suggested.

630. HAZARD MINIMIZATION MEASURES

Both implemented (field 631) and planned (field 632) countermeasures are described in this sub-section. For instance:

631. *Partial restriction of the contaminated land use, strict control for radionuclide content in milk and other agricultural products.*

632. *Contaminated lands' treatment with lime, introduction of higher doses of potassium fertilizers into the contaminated soils.*

700. RESTORATION STRATEGIES AND TECHNIQUES

710. RESTORATION MEASURES TAKEN

Any previous activities aimed at decontamination or remediation of the site and results achieved should be described in the fields Nos. 711–728. Information can be also presented in a form of matrix (see Table A2-3).

A description of the sequence of clean-up measures together with major milestones will be sufficient. A list of techniques used during the clean-up operations will be also desirable.

Table AII-III. Restoration measures taken at the site

Sub-site	Measure	Technique applied	Time period (date)	Results	Cost estimate
A					
B					
C					
…					
X					

730. RESTORATION MEASURES PLANNED

Planned activities on the site restoration should be presented in forms similar to those given above.

900. PUBLISHED INFORMATION/DATA ON SITE

In this section description of information/data sources — published professional communications (sub-section 910), electronic data sources (sub-section 920), mass-media publications (sub-section 930) — should be given in the proposed forms. For instance:

911. *0001*

912. *Fesenko S.V., Alexakhin R.M., Sanzharova N.I , Lisyanskii B.G.*

913. *1998*

914. *The Assessment of Strategies of Countermeasures' Application in the Agriculture After the Accident at Chernobyl NPP*

915 *Journal article*

916.1. *Radiatsionnaia Biologiia. Radioecologiia (Radiation Biology. Radiation Environmental Science)*

916.2. *38*

916.3. *5*

916.4 *721–728*

916.6. *Russian*

916.7. *0869-8031*

917.1. *Swets International Moscow*

917.2. *Russia, Moscow*

917.3 *www.swets.nl*

919. *Justification of an approach to estimation of the efficiency of countermeasures strategies is presented for agricultural activities at radioactively contaminated territories. Results of the assessment of protective measures' strategies in agriculture after the Chernobyl accident are given. The time period between* *radioactive fallout and the protective measures' application is shown to be one of the major factors, determining the countermeasures' efficiency.*

921. *0012*
922. *CASurveyor- Waste Management and Remediation*
923. *Chemical Abstracts Service*
924. *Treatment of wastewater, solid waste, nonaqueous waste and radioactive waste, waste site remediation, soil pollution remediation, regulatory aspects*
925. *3+ years*
927.1 *43210 Columbus, OH, USA*
931. *0008*
932. *Shishlov A.E.*
933. *1997-03-25*
934 *On the Radioecological Situation in the MCC Location Area*
935. *Daily evening newspaper*
936.1. *Vechernii Krasnoyarsk*
936.2. *41*
936.3 *3*
936.4. *Russian*
937. *Russia, Krasnoyarsk*

Appendix III

SAMPLE SELECTIONS FOR DROP-DOWN MENUS

311 Former Disposal Practices

- shallow burial without liner and capping
- shallow burial without liner with capping
- shallow burial with liner without capping
- shallow burial with liner and capping
- borehole injection
- release into surface waters
- surface storage
- transshipment facility
- waste conditioning facility
- storage tanks, metal
- storage tanks, concrete
- n.n.

315 Extraction and processing of materials containing natural radionuclides

- Uranium/thorium mining
- Metal mining
- Phosphate mining
- Rare earth mining
- Fertiliser production
- Radium mining
- Radium application, industrial
- Metal smelting
- Lignite mining
- Coal/lignite combustion
- Coal mining
- n.n.

463 Current Land-use

- agricultural
- ash tip
- building land
- car maintenance yard
- cemetery
- chemical industry
- commercial site, operational
- commercial site, disused
- creek
- clay pit
- domestic landfill
- filled-in valley
- fire brigade training ground
- fish pond
- forestry
- garages
- garden, private
- gardener, market
- gravel pit
- hazardous landfill
- historic city
- industrial site, operational
- kindergarden
- lane
- market garden
- military site, disused
- military site, operational
- mine, closed
- mine, operational
- mine shaft
- mine shaft, engine house
- mining spoil tip
- mining tip
- paper mill
- park
- parking lot

463 Current Land-use continued

- pasture
- pond
- orchard
- pond
- railroad
- railroad shunting yard
- railroad station
- railway land
- recreation
- reacreational lake
- recultivated land
- residential
- residential area
- residence home
- residual open pit mine
- river
- road
- sealed land
- sewage treatment plant
- slag heap
- sludge disposal
- small garden plots
- smelter
- spoil heap
- spoil heap, former
- spoil heap, recultivated
- sports ground
- storage yard
- suburban area
- swimming pool
- village
- water works
- waste land
- waste disposal site
- workshops
- n.n.

521.1 Type of contaminated medium

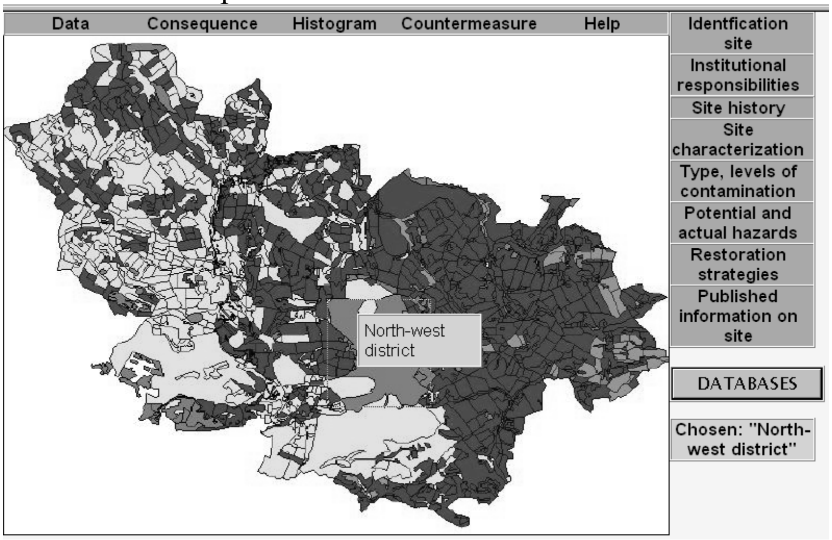
main category → **sub-category** → **type**

- air
  - Radon
    - Rn in ambient air
    - Rn in soil air
  - particles
- water
  - surface
    - river
    - lake
    - creek
    - open pit mine drainage
    - seepage waters
  - under ground
    - groundwater
    - soil pore water
    - underground mine drainage
    - seepage waters
- solids
  - sediment
    - lake sediments
    - river sediments
    - clay
    - sand
    - gravel
  - soil
    - topsoil
    - A horizon
    - B horizon
  - mining residues
    - spoil material
    - ore
    - low-grade ore
    - tailings
    - mine debris
  - building materials
    - brick
    - concrete
    - mortar
    - infill
    - rubble and debris
- biota
  - plants, wild
    - berries
    - mushrooms
  - plants, cultivated
    - (leavy)
    - (roots)
    - (cereals)
    - (nuts)
  - animals, wild
    - deer
    - boar
    - rabbits
    - hares
    - water fowl
  - animals, domestic
    - bovines
    - pigs
    - sheep
    - goats
    - ducks
    - geese
    - chicken

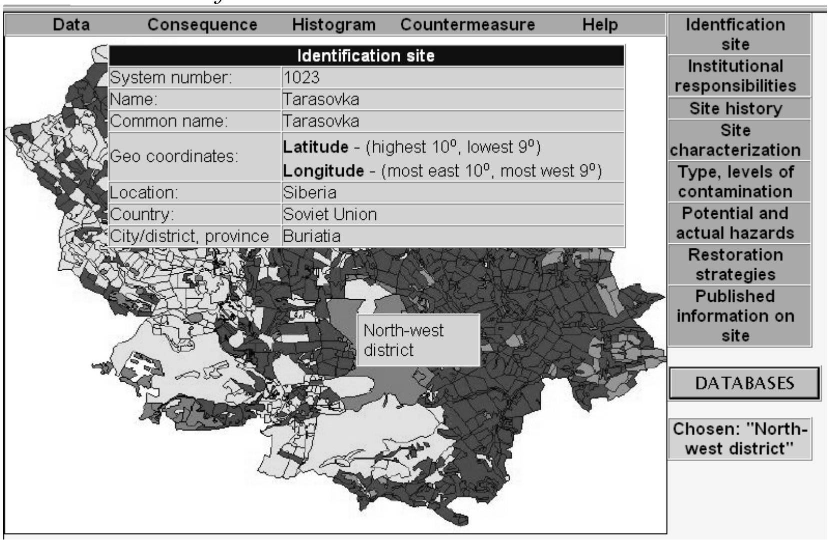
Appendix IV

SCREENSHOTS FROM PROTOTYPE DRCS 'FRONT END'

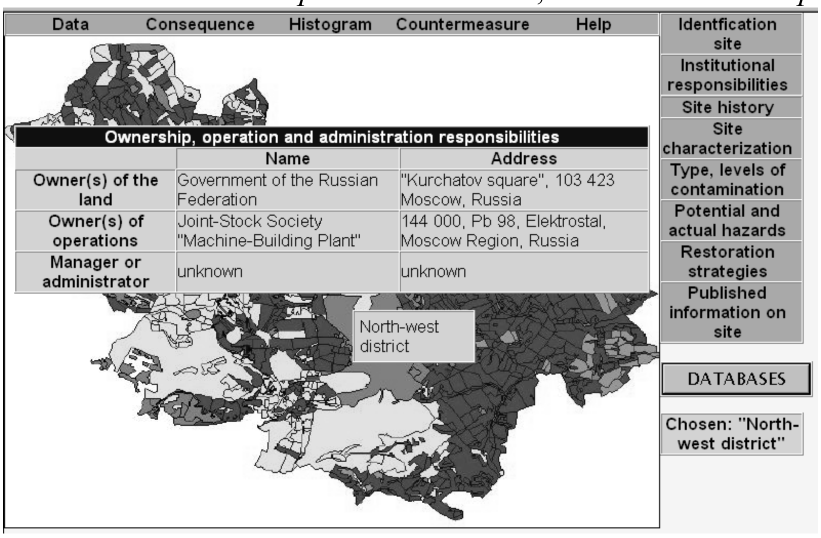
Select site on map



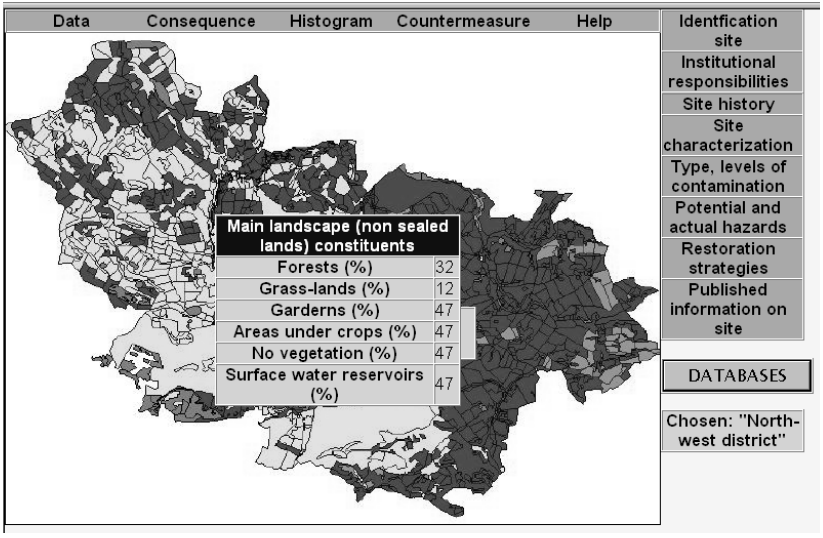
Select *Site Identification*



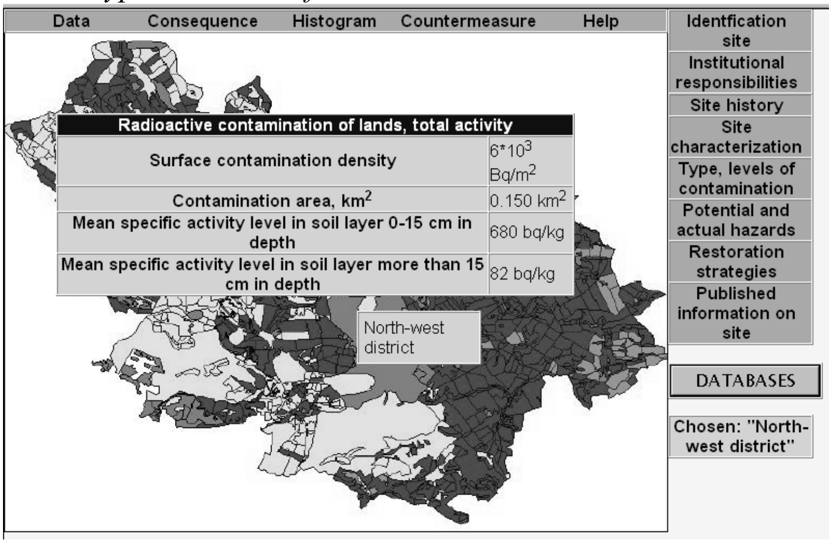
Select *Institutional Responsibilities* menu, submenu *Ownership etc.*



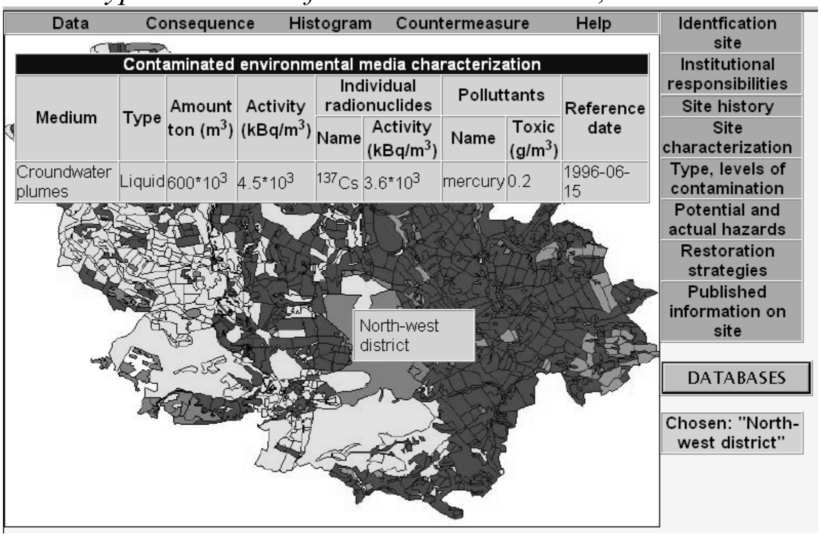
Select *Site Characterisation*, submenu *Land Use*



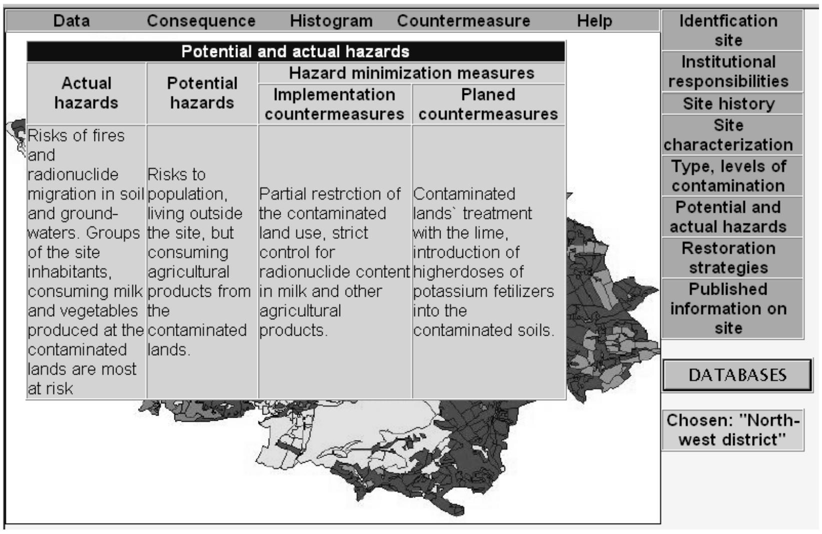
Select *Type and Level of Contamination* menu



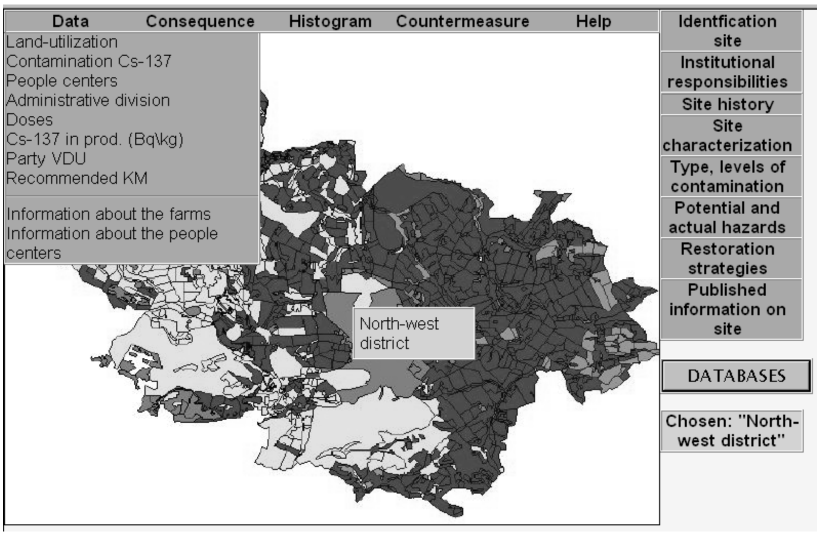
Select *Type and Level of Contamination* menu, sub-menu *Contaminated Media*



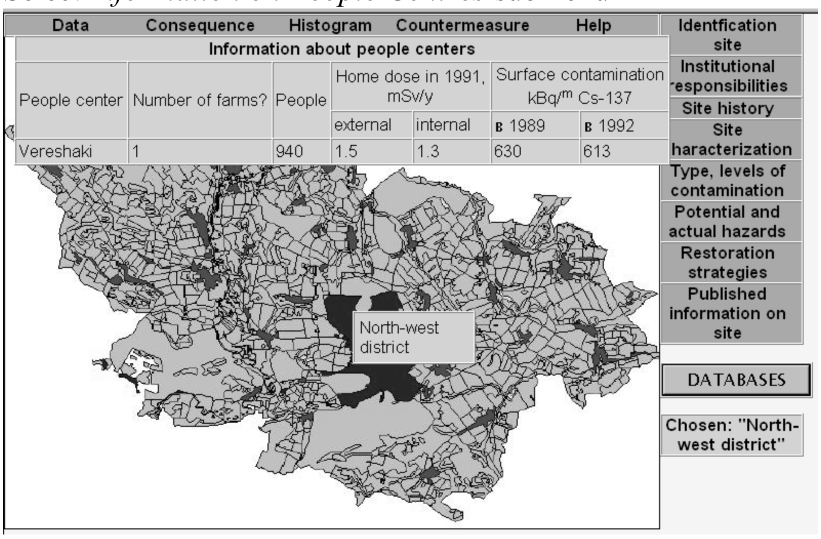
Select *Potential and Actual Hazards* menu



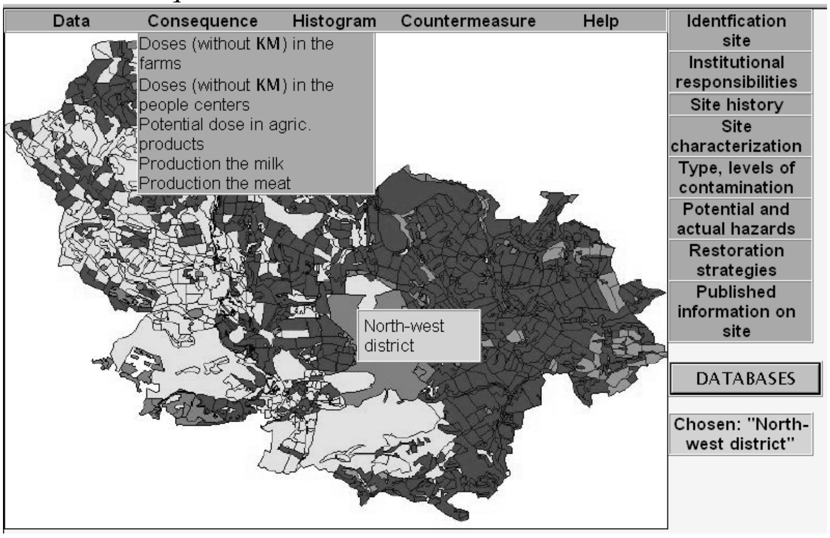
Select *Data* menu



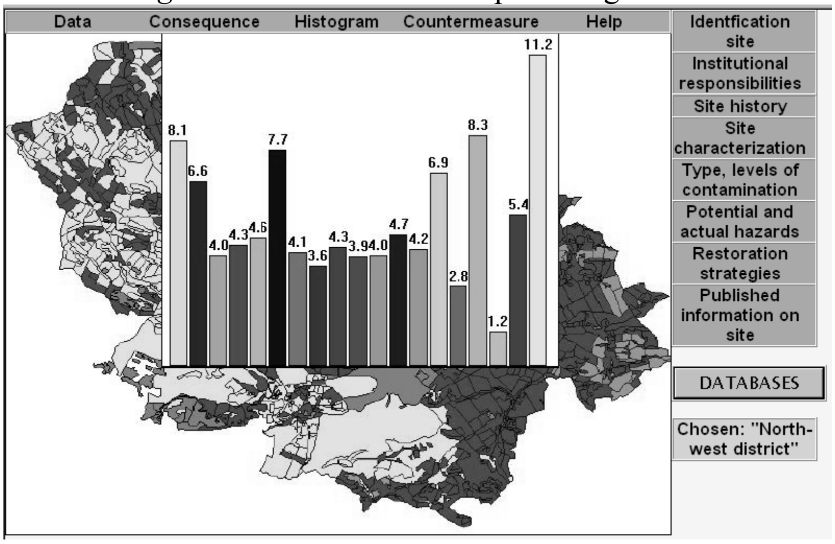
Select *Information on People Centres* submenu



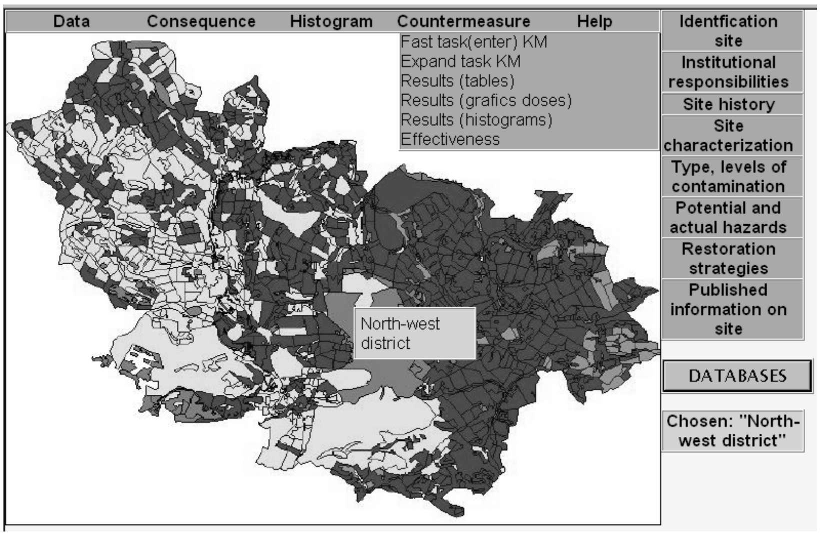
Select *Consequences* menu



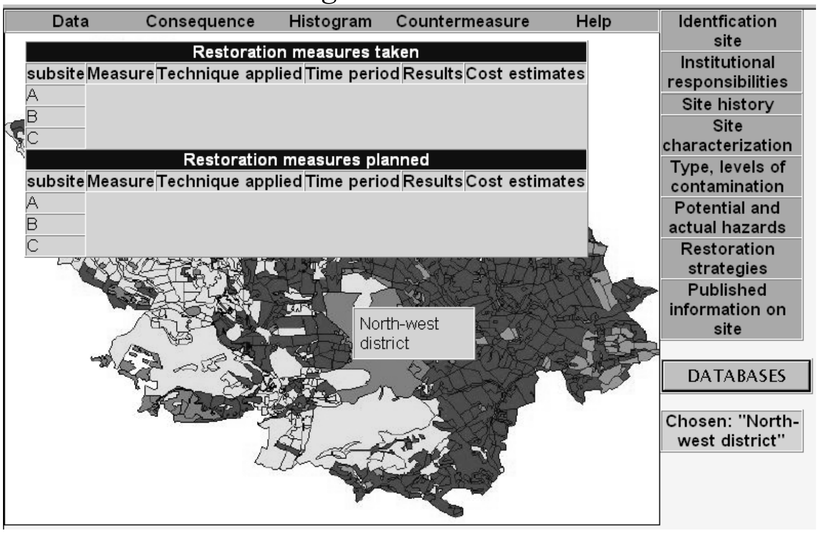
Select *Histogram* menu and show sample histogram



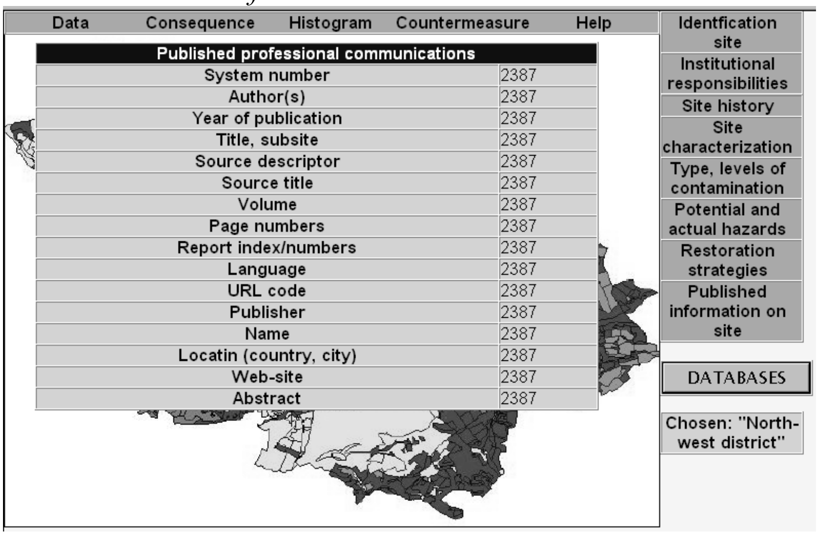
Select *Countermeasures* menu



Select *Restoration Strategies* menu



Select *Published Information on Site* menu



Annex A

SUMMARY OF RESPONSES TO THE 1996 QUESTIONNAIRE

Country	***Australia***
Name	***Maralinga***
Location	South Australia. major contamination is at Taranaki about 40 km north of the Maralinga village.
Operations or events leading to contamination	Nuclear explosives testing (7 tests) and ancillary experiments involving explosive dispersal or burning of metallic plutonium, uranium, and beryllium in the open environment.development: One large site.
Contaminants	Am-241, Pu-239, K-40, Pb-210, Ra-226, Ra-228, Th-228, U-238 (also detection of Co-60, Cs-137) Distribution: Surface soils 132 Km Mixed Soils: 2.2 km
Remediation oversight	Regulation and control of remediation operations: Australian Radiation Laboratory (ARL) Department of Health
Execution of remediation work	Department of Primary Industries & Energy Commonwealth Government of Australia
Status and strategy	Currently planing and characterizing the site. Plan to complete characterization, stabilize and monitor, use in-situ treatment, and retrieve and dispose. *For mixed soils:* removal of soil for burial in trenches, *Surface plumes:* institutional marker posts around 120 km^2 *Of land debris pits:* in situ vitrification
Needs	Access, characterization/monitoring, stabilization, retrieval , in-situ treatment, information management, trench burial technologies; financial resources, trained personnel.
References	Cited
Survey completed by	Department of Primary Industries and Energy, Rehabilitation/Radioactive Waste Policy Branch.

Country	***Belarus***
Name	***Chernobyl accident fallout***
Location	SE Belarus - Gomilskaya, Mogilevska, Brestskaya, Minskaya, Grodnenskaya, Bitebskaya Oblasts
Operations or events leading to contamination	Nuclear Facility Accident (From Chernobyl, Ukraine)
Contaminants	Cs-137, Sr-90, Pu-238,-239,-240.
Remediation oversight	Environmental Committee for Hydrometeorology of Belarus, Radiation Control and Monitoring Center
Execution of remediation work	
Status and strategy	
Needs	23% of territory contaminated, characterization and monitoring, In situ treatment, information mgmt technologies; and financial resources
References	Cited and provided
Survey completed by	Environmental Committee for Hydrometeorology of Belarus, Radiation Control and Monitoring Center

Country	*Belarus*
Name	*Brestskaya*
Location	Uranium ore railroad transfer point, Brestskaya town, Brestskaya Oblast.
Operations or events leading to contamination	Contamination as a result of uranium ore railroad transfers
Contaminants	U-238, K-40, Ra-226, Th-232 (in soil) over 18,475 m^2
Remediation oversight	Environmental Committee for Hydrometeorology of Belarus, Radiation Control and Monitoring Center
Execution of remediation work	
Status and strategy	
Needs	Characterization and monitoring, -n situ treatment, information mgmt technologies; and financial resources
References	Cited and provided
Survey completed by	Environmental Committee for Hydrometeorology of Belarus, Radiation Control and Monitoring Center

Country	*Bosnia/Herzegovina*
Name	
Location:	War destroyed buildings throughout country
Operations and events leadina to contamination:	(1) Production, handling and use of radionuclides (radioactive paints - 1 site) and (2) Accidental releases (smoke detectors in damaged buildings (multiple sites).
Contaminants:	Ra-226 and Am-241
Remediation oversight:	Center for Radiation Protection and Safety, National Institute of Public Health
Execution of remediation work	
Strategy and status:	no characterization conducted but planned. Currently in planning stage
Needs:	Information management technologies; financial resources, training
References	
Survey completed by:	Center for Radiation Protection and Safety, National Institute of Public Health

Country	*Finland*
Name	*1) Askola; 2) Paukkajavaara; 3) Korsnas Lead Mine*
Location	1) Askola Municipality; 2) Eno Municipality; 3) Province of Vaasa
Operations and events leadina to contamination	Conventional mining and chemical processing activities (refining of uranium on experimental scale, mining)
Contaminants	Varying but less than: U in soils <6.81 Bq/g; Th in soil <0.02 Bq/g; Rn groundwater <165 Bq/1)
Remediation oversight	Finnish Centre for Radiation and Nuclear Safety (STUK)
Execution of remediation work	
Strategy and status	1) Characterisation and partial remediation complete, retrieve and dispose planned; 2) Full remediation completed, plus future restrictions on land use; 3) No activity, unknown strategy at this time.
Needs	Stabilization, in situ treatment, financial resources for some
References	Cited
Survey completed by	Finnish Centre for Radiation and Nuclear Safety

Country	***France***
Name	***reported 11 different sites***
Location	various
Operations and events leadina to contamination	Uranium mining and various nuclear fuel cycle and research activities
Contaminants	various
Remediation oversight	Ministry of Health, Defense Ministry, CEA
Execution of remediation work	in varying stages
Strategy and status	varying
Needs	
References	Cited
Survey completed by	

Country	***Gabon***
Name	***Mounana***
Location	Se Gabon, Haut-Ogooue' Province
Operations and events leading to contamination	Conventional mining and chemical processing activities.
Contaminants	Soils: U-238 (50–1000 ppm), Ra-226 (0–26 Bq/g); Surface waters: U-238 (2–10 mg/1), Ra-226 (1–10 Bq/L); Ground Water: none detected
Remediation oversight	Ministere des mines, de L'Energie et Du Petrole
Execution of remediation work	
Strategy and Status	Strategy is to characterize, stabilize and monitor, and treat in situ. Currently conducting characterization.
Needs	Characterization/monitoring, in situ treatment technologies; financial resources, trained personnel
References	Cited
Survey completed by	Ministere des Mines, de I'Energie et du Petrole

Country	***Germany***
Name	various **(**Questionnaire not completed by Germany, but information letter and overview paper provided)
Location	Especially Saxony, Thuringia, and Saxony-Anhalt
Operations and events leading to contamination	Ore and mineral mining
Contaminants	Pb-210, Po-210, Ra-226, natural uranium. Suspected over 1,500 km^2 waste dumps of residues and radioactive contaminated areas due to ore and mineral mining
Remediation oversight	Federal Office for Radiation Protection
Execution of remediation work	
Strategy and status	Strategy is to characterize and remediate where necessary. Currently in process of characterization
Needs	
References	Cited and provided
Survey completed by	

Country	***Hungary***
Name/	***Pestvidék*** Machine (Aeroplane) Factory
Location	Pest Country
Operations and events leading to contamination	Production, handling and use of radionuclides (use of luminising sources)
Contaminant	Ra-226 (1–80 Bq/g), 80–100 m^2 of soil
Remediation oversight	Pest County Institute of State Public Health and Medical Officer Services (SPHAMOS)
Execution of remediation work	n.a.
Strategy and status	Remediation completed
Needs	n.a.
References	Cited and provided
Survey completed by	Natural Resources Institute for Radiobiology and Radiohygiene

Country	***Kenya***
Name	Materials Testing And Research Department - Physics Laboratory
Location	?
Operations and events leading to contamination	Handling of industrial, research and medical materials (disposal site for spent sealed sources from hospital and spent industrial radiography isotopes)
Contamination	Unspecified and unclear if there is actual contamination.
Remediation oversight	Ministry of Health and Ministry of Public Works and Housing
Execution of remediation work	
Strategy and Status	Strategy is to eventually remove drums of waste to new disposal site. Conducting monitoring of waste site, final disposal site has yet to be designated.
Needs	Characterization and monitoring technologies, financial resources
References	
Survey completed by	Materials Testing and Research Department - Physics Laboratory

Country	***Lithuania***
Name	***Maishiagala*** Radioactive Waste Repository
Location	Sirvintos Province
Operations and events leading to contamination	Production, handling, and use of Radionuclides (disposal of radioactive materials - waste repository leakage)
Contamination	*Soils:* Pb-214 (0.180 Bq/g), 130i (0.89 Bq/g), Tl-208 (0.031 Bq/g), Cs-1 37 (0.012 Bq/g), K-40 (0.394 Bq/g) *Groundwater:* Pb-214 (0.15 Bq/L), 134i (0.89 Bq/L), Tl-208 (0.04 Bq/1), Cs-1 37 Bq/1), K-40 (1.58 Bq/1) *Grass:* Cs-137 (0.021 Bq/g), K-40 (0.0359 Bq/g) *Marsh Flora:* Cs-1 37 (0.037 Bq/g), K-40 (1,785 Bq/g)
Execution of remediation work	
Strategy/status	Strategy is to continue to characterize site, stabilize and monitor. Currently characterizing site.
Needs	Access (i.e. drilling), characterization/monitoring, retrieval, waste packaging technologies; financial resources. An "International assessment".
References	
Survey completed by	Environmental Protection Ministry

Country	***Peru***
Name	***Bayovar***
Location	Piura, Near North Coast Of Pacific Ocean, Peru
Operations and events leading to suspected contamination	Production, handling, and use of radionuclides (Production of phosphoric acid/phosphates)
Contamination	None found at this time
Remediation oversight (if exercised)	Instituto Peruano de Energia Nuclear (WEN).
Execution of remediation work	
Strategy and status	No actions are planned, no actions are currently underway
Needs	
References	
Survey completed by	Instituto Peruano De Energia Nuclear, Oficina Tenica De La Autoridad Nacional

Country	***Philippines***
Name	***Philphos***
Location	Phosphogypsum Storage Pile, Isabel, Leyte, Island of Visayas, Central Philippines
Operations and events leading to suspected contamination	Production, handling, and use of Radionuclides (Production of phosphoric acid/phosphates - suspected)
Contamination potential	U-238 and Th-232
Remediation oversight	Philippine Nuclear Research Institute (radioactive component), Department of Environment and Natural Resources (environmental aspects)
Execution of remediation work	
Strategy and status	Strategy is to characterize site. Currently no action has been taken
Needs	Characterization/monitoring, in situ treatment, waste packaging technologies; scarce financial resources, lacking trained personnel
References:	Cited and provided
Survey completed by	Health Physics Research Section, Philippine Nuclear Research Institute

Country	***Slovakia***
Name	***Bohunice***
Location	Jaslovske' Bohunice Environs, Western Slovak Republic.
Operations and events leading to suspected contamination	Accidental release (nuclear facility accident)
Contamination	Cs-137, (6–7 Bq/g in soils)
Remediation oversight	Ministry of Health of Slovakia, Ministry of Environment of Slovakia, Nuclear Regulatory Authority of Slovakia
Execution of remediation work	
Strategy and status	Strategy is to retrieve and dispose. Currently in characterization stage
Needs	Characterization/monitoring, retrieval technologies
References	Cited and provided
Survey completed by	Ministry of the Health of Slovakia

Slovenia did not complete questionnaire but mentioned incidents of potential radioactivity associated with coal ash dumping sites in response.

Country	***USA***
Name	See Below
Location	See Below
Operations and events leading to suspected contamination	*Nuclear explosives testing:* Los Alamos National Lab, Nevada off-site locations, Nevada Test Site *Nuclear weapon fabrication:* Hanford, Idaho National Eng. Lab, Los Alamos National Lab, Mound Plant, Oak Ridge K-25 Site, Oak Ridge Y-1 2, Pantex Plant, Rocky Flats Technology Site, Sandia National Laboratories/New Mexico, Savannah River Site *Production, handling and use of radionuclides:* (US DOE facilities): Ames Lab, Argonne Lab, Battelle Columbus, Brookhaven, Fernald Env. Mgmt Proj., FUSRAP (several sites), General Atomics, Idaho Nat Eng. Lab, Inhalation Toxicology Research Institute, Lab for Energy-Related Health Research, Lawrence Berkeley National Laboratory. Lawrence Livermore National Laboratory, Los Alamos National Lab, Mound Plant, Nevada Test Site, Oak Ridge K-25 Site, Oak Ridge National Lab, Oak Ridge Y-12, Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, Reactive Meals, Inc, Rocky Flats Technology Site, Sandia National Lab/New Mexico, Santa Susana Field Lab. Savannah River Site, Separations Process Research Unit, Weldon Spring Site. *Nuclear Regulatory Commission Oversight:* 47 additional sites *Accidental release:* Rocky Flats Environmental Technology Site
Contamination	Wide spectrum
Remediation oversight by	*Implementation:* US Department of Energy *Regulation:* US Environmental Protection Agency *Regulation:* Nuclear Regulatory Commission
Execution of remediation work	
Strategy and status	All stages
Needs	Wide Spectrum
References	
Survey completed by	Department of Energy, Office of Environmental Restoration

Annex B

EXAMPLES OF NATIONAL REGISTRIES OF CONTAMINATED SITES

Annex B-1. The Belgian national inventory of nuclear facilities and sites containing radioactive substances

1. THE LEGAL FRAMEWORK RELATED TO DECOMMISSIONING AND SITE INVENTORIES

Legal assignments regarding the inventory of nuclear facilities since 1991 have been entrusted to the National Agency for Radioactive Waste and Enriched Fissile Materials, the agency. The responsibilities involve:

- the collection and evaluation of information concerning the decommissioning programmes for nuclear facilities,
- the approval of decommissioning programmes,
- the elaboration of mechanisms for building up financial provisions for the execution of programmes, in agreement with the operators or the owners of the facilities,
- the execution of decommissioning programmes as requested by owners or in case of failure.

These legal assignments were extended in December 1997 to all sites containing radioactive substances presenting a risk for the public health or for the environment in the country. The agency is in charge of drawing up and reviewing every five years a national inventory comprising a database of all facilities and sites concerned, and of assessing their decommissioning and restoration costs. The agency is also responsible for verifying the existence of sufficient financial provisions to cover the (future) execution of the programmes [4]. An annual report on the situation must be submitted to the supervising ministry that may require the responsible body to take the necessary actions to avoid further uncovered “nuclear liabilities”.

2. THE IMPLEMENTATION OF THE LEGAL REQUIREMENTS

The agency has set up a methodology and has developed the necessary technical and administrative means to fulfil its legal assignments. One of the main tools consists of an integrated data processing system comprising a set of databases and a decommissioning programme evaluation tool. This system is commonly used for all the activities of the agency with regard to decommissioning.

2.1. Decommissioning planning

To fulfil its legal assignments related to the collection and evaluation of decommissioning programmes of nuclear plants in Belgium, the agency has defined and implemented decommissioning plans, based on the recommendations by the IAEA. With a view to standardising the transfer of information, the agency issued recommendations for drawing up these decommissioning plans which are submitted to the agency for approval.

2.2. The national inventory of nuclear facilities and contaminated sites

the agency started with the collection of information for this national registry in 1999. The first step was the completion of data on Class 1 (see Section 3.1) licensed nuclear facilities. The second step is in 2000–2001 the collection of data on Class 2 licensed facilities, covering particle accelerators, irradiators, laboratories in the non-nuclear industry using or processing radio-isotopes, radioactive sources or X-ray generators. This step is now in progress. Class 3 licensed facilities and non licensed sites will be investigated in 2001 and later.

The agency uses, as much as possible, its existing methodologies and tools. The transfer of information concerning installations and sites from the operators and the holders of such substances to the agency is organised by means of a questionnaire which is specific for each type of facility (nuclear Class 1 or 2 plants, nature of the activity) or site (nature of the radiological contamination).

3. THE SITUATION AT THE END OF 2000

3.1. Class 1 licensed facilities

The Class 1 licensed facilities in Belgium include the following:

- Two nuclear sites for electrical power generation at Tihange and Doel with a total of seven nuclear reactors of the PWR-type [2];
- Two nuclear fuel fabrication plants at Dessel;
- One nuclear research centre at Mol containing three research reactors and several laboratories [3];
- One research reactor at the University of Gent;
- One research institute of the European Commission at Geel [1];
- A former reprocessing plant at Dessel which is currently under decommissioning and the site of which is used for the centralised processing and storage of Belgian radioactive waste [2];
- A historical waste processing and storage site which is currently under partial decommissioning [2];
- An institute for isotope production for medical applications at Fleurus.

3.2. Classes 2 and 3 licensed facilities

Some 620 sites are or were licensed in the past as Class 2 facilities. They include 29 cyclotrons, 45 medical accelerators and 310 X-ray generators. Most of the Class 3 licensed equipment (about 700 items) also comprises X-ray generators or radioactive sources for medical applications.

3.3. Non-nuclear facilities

A comprehensive inventory of radioactively contaminated sites from non-nuclear activities is not available at this time. Nevertheless, some sites are commonly known as radioactively contaminated from present or past activities, mainly from former industries using or processing radium [6]. For some of them, investigations are underway by the regulatory body with the aim to decide whether remediation actions are necessary or not.

REFERENCES TO ANNEX B-1

[1] BRAECKEVELDT, M., VERBEKE, R., SCHRAUBEN, M., VERSTRAETEN, I., "Decommissioning and its financing in Belgium: better to prevent than to cure", IDS2000, Knoxville, Te., 12–16 June (2000).

[2] http://www.electrabel.be/index_noflash2.htm (16/05/01).

[3] http://www.sckcen.be (16/05/01).

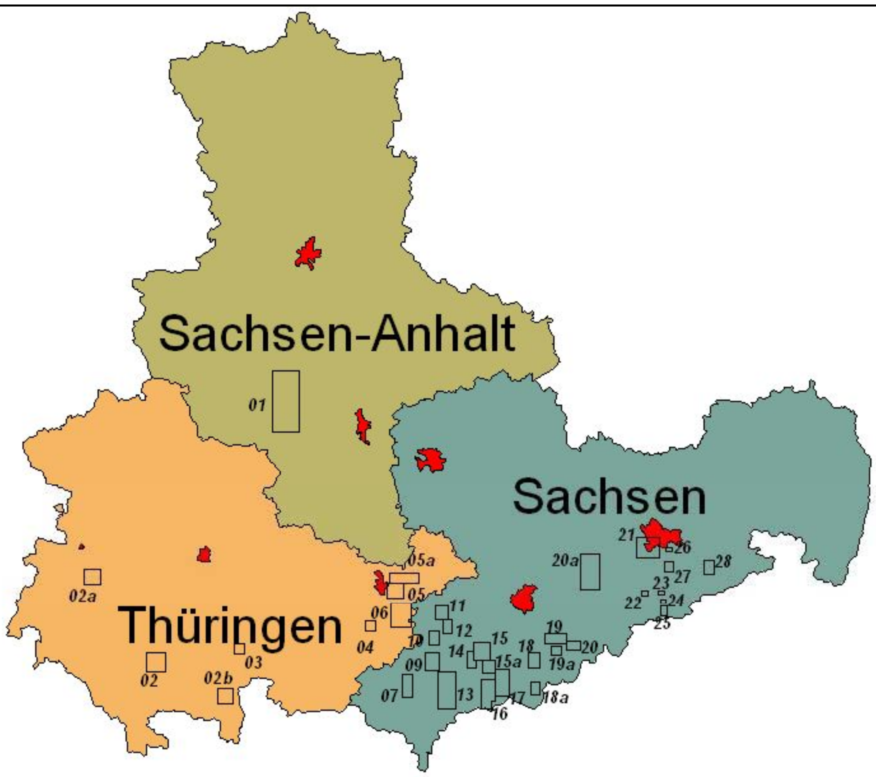
[4] http://www.irmm.jrc.be/ (16/05/01).

[5] http://www.belgoprocess.be/03_act/03_decom_02.html (21/11/00).

[6] COTTENS, E., et al., "Contamination and possibilities for remediation in the vicinity of the former radium extraction plant in Olen: a case study", Proc. EC-International Symp. "Remediation and Restoration of Radioactive-Contaminated sites in Europe", Antwerp, 11–15 October 1993, Doc. XI-5027/94 (1993) 263–280.

Annex B-2. Registry of mining residues in Germany

In the Federal States of Saxony, Thuringia, and Saxony-Anhalt thousands of sites with residues from past mining activities with enhanced levels of natural radioactivity are to be found. Within the framework of a Federal project, between 1991 and 1998 these sites were registered, investigated and evaluated for their radiological relevance. The objective was to arrive at an overview of the radiological situation in the affected region as a whole, and to identify such sites, for which remedial actions should be considered. Figure B-1 gives an overview of the areas within which the majority of investigations were carried out. These so-called 'suspect' areas were defined on the basis of information on former mining activities and of results from airborne radioactivity surveys.



1	Hettstedt	7	Mechelgrün-Zobes	16	Johanngeorgenstadt	21	Freital
2	Suhl	9	Lengenfeld	17	Pöhla	22	Schmiedeberg
2a	Ruhla	10	Gospersgrün	18	Annaberg-Buchholz	23	Bärenhecke
2b	Steinach	11	Oberrothenbach	18a	Bärenstein	24	Kesselhöhe
3	Dittrichshütte	12	Zwickau	19	Marienberg	25	Altenberg
4	Göhren-Döhlen	13	Gottesberg	19a	Niederschmiedeberg	26	Sobrigau
5	Ronneburg	14	Filzteich	20	Pobershau	27	Mühlbach/Maxen
5a	Drosen	15	Schneebrerg-Aue	20a	Freiberg	28	Königstein
6	Seelingstädt	15a	Lauter				

FIG. B-1. Location, identification numbers, and names of 'suspect' areas.

The handling of data and information on more than 8000 sites with mining residues necessitated the use of computer supported data processing right from the start. Different computational facilities were added in order to meet the requirements of an increasing level of detail of the investigations during the different phases of the project. The starting point was a PC-based database named A.LAS.KA that mainly contained the basic information on the individual contaminated sites and the results of a relatively small number of simple radiological measurements (dose rates).

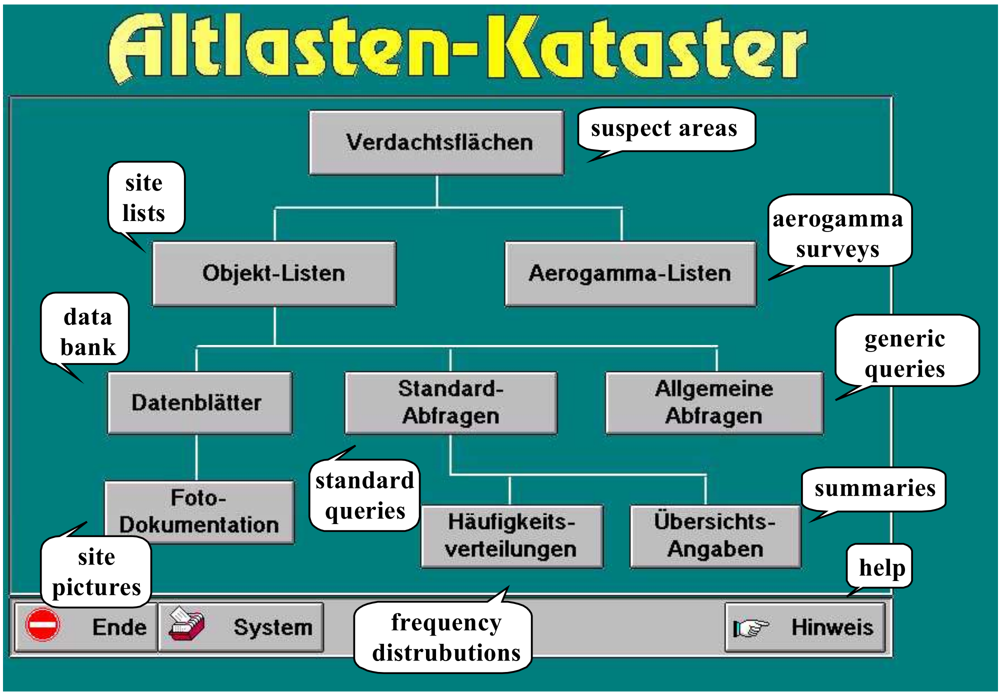


FIG. B-2. Main menu screen of "A.LAS.KA".

Table B-I. Contents of the PC-database

Category	Contents
basic object data	type and location of objects, size, use ...
unusual occurrences	e.g. landslides, vegetation damages ...
technical facilities	covers, sealing, fences ...
composition of the material	rock/soil types, grain size distributions ...
protected goods	kind, distance from site...
gamma dose rate	measurement results, type of instrumentation ...

Using these data a first radiological evaluation was undertaken. Data collection was also extended to a variety of non-radiological parameters in support of this purpose, for example information on the (historical) use of the sites. Table B-I summarizes the main contents of the database.In addition to its function as a working tool, during the further course of the project the computer-supported database permitted a quick and uncomplicated handing over of information gathered to other interested parties, in particular the radiation protection authorities in the Federal States concerned.

Sites of minor radiological importance were quickly dealt with. At the more important sites, thousands of samples of soils, contaminated materials and different environmental media were taken, and several hundreds of thousands determinations of local dose rates were carried out during the last project phase. The large volume of data and their spatial relationship called for the use of a geographical information system (GIS). This forms the basis of the register of contaminated mining sites now being used by the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz). A new quality of data evaluation and presentation is achieved by the use of a GIS. Of course, this new format of Register also contains the basic site data as described in Table B-1. Figure B-3 shows the main components and structure of the database.

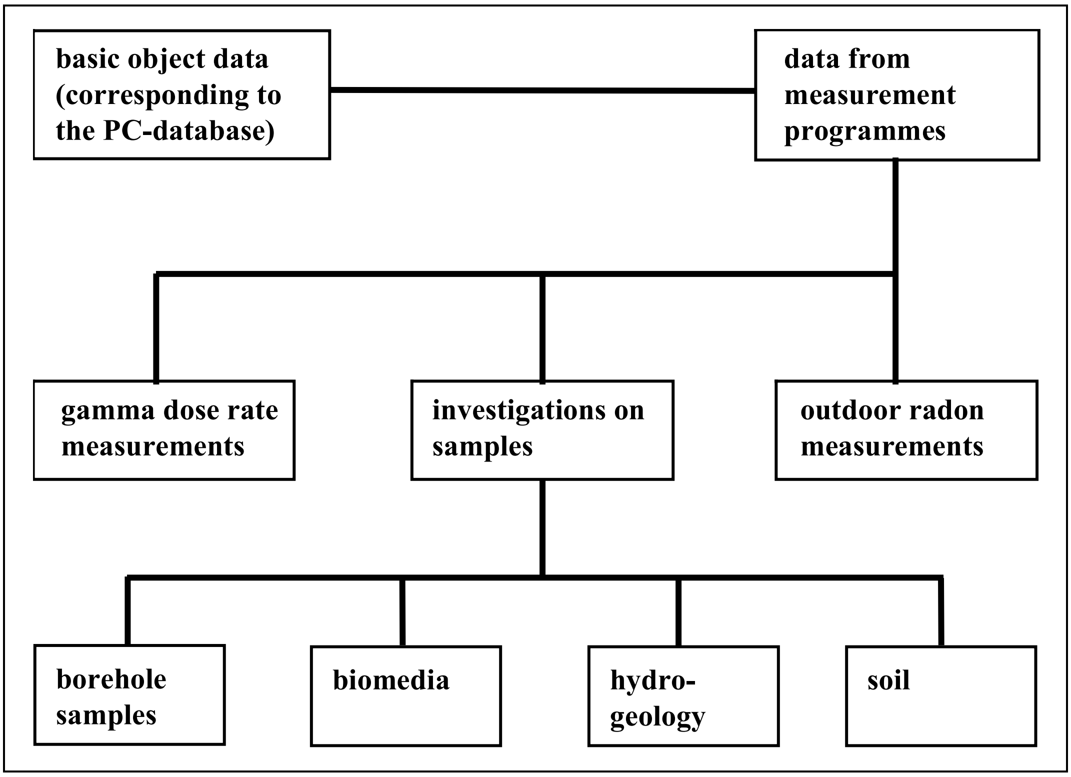


FIG. B-3. Schematic representation of the main sub-databases.

It is the primary purpose of the Register to support the evaluation and assessment of the data collected within the framework of measurement programmes. This is facilitated by a variety of functions, such as

— Spatial selection of information
— Presentation of results in different formats (maps, tables, graphics)
— Simple statistics
— Photo-documentation of the sites (CD-ROM)
— Print function
— Interfaces to standard proprietary software (MS-EXCEL™).

For example, in Figure B-4 the selection of information from the register using GIS-functions is shown. Figure B-5 shows the results of spatial interpolation of dose rate measurements for the residues (waste rock dumps) selected and their immediate surroundings.

It is beyond the scope of to this Federal project to arrive at final conclusion on the need for remedial measures. Further sites-specific investigations and exposure assessments are required in many instances. The contents of the Register, as well as its functionalities, as they stand now, however, have already considered the requirements of up-coming site-specific investigations and, therefore, form a viable basis for these undertakings. Currently, some additional tools are being developed to facilitate these investigations. These tools include, among others, interfaces to other software packages, for instance, a dose assessment code specifically designed for the problem of radioactively contaminated mining sites.

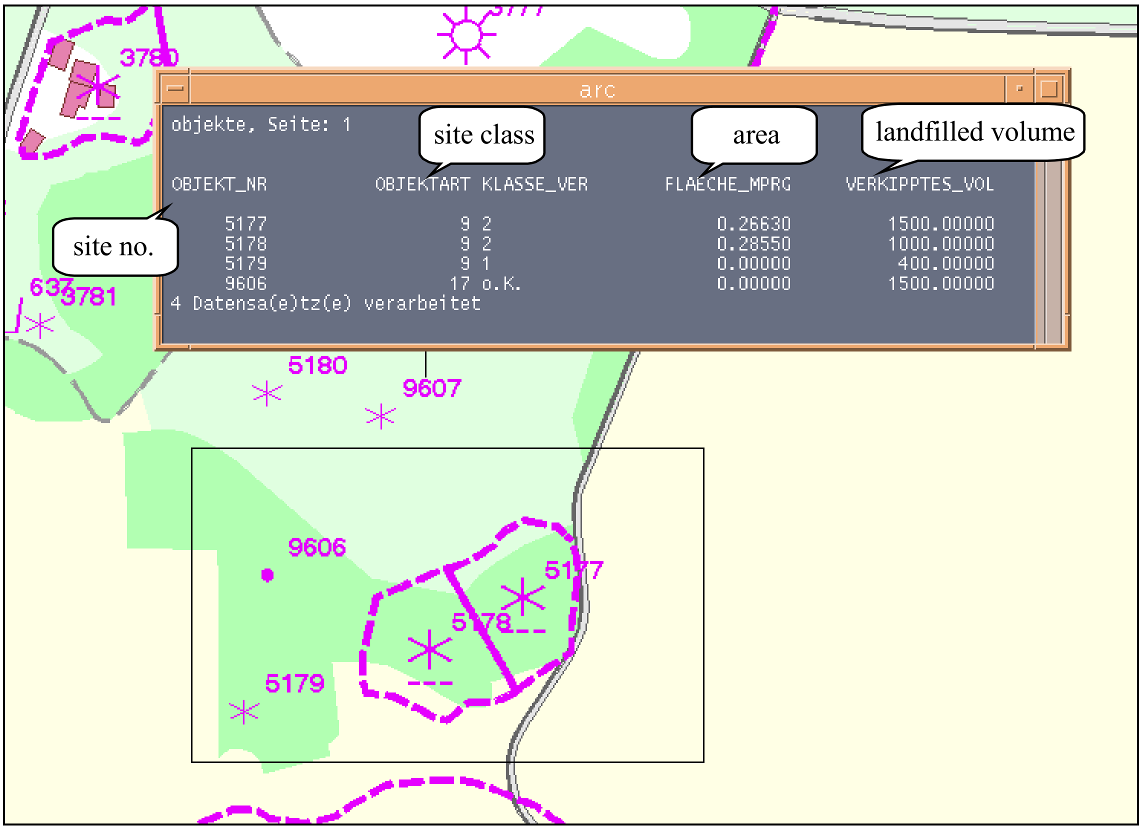


FIG. B-4. Selection of information on residues using GIS-functionalities.

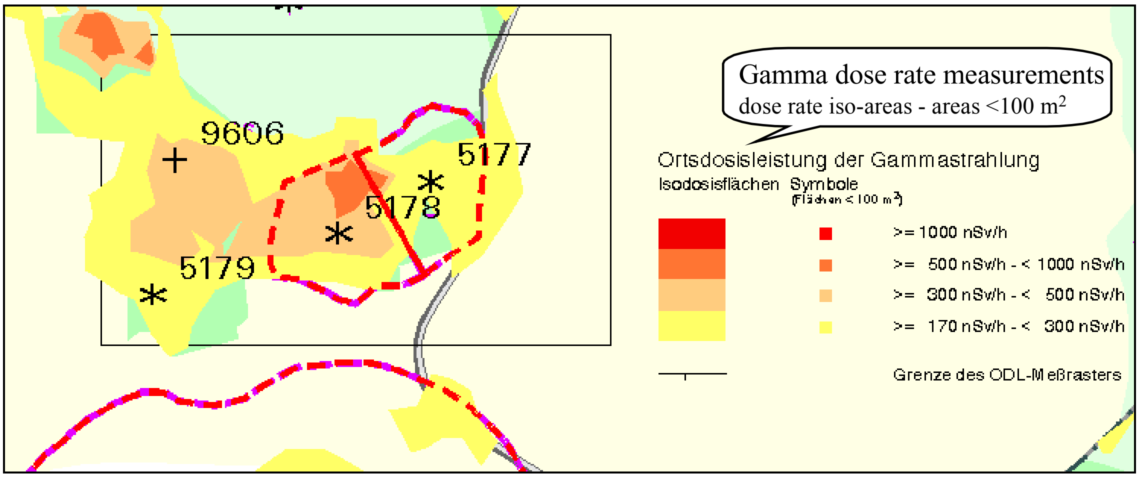


FIG. B-5. Results of spatial interpolation of dose rate measurements for the selected objects and their surroundings.

REFERENCE TO ANNEX B-2

[1] GEHRCKE, K., BIESOLD, H., "Development of a Computer-Based Information System for the Registration, Investigation and Radiological Assessment of Mining Residues", Proc. Third Int. Symp. Environmental Contamination in Central and Eastern Europe, Warsaw, Poland, September 10–13, 1996 (1996) 769.

Annex B-3.National inventory of radioactive wastes in France

A somewhat different type of a registry exists in France. Its aim is to maintain the controls over all sites in France and in the French Overseas Territories which accommodate radioactive waste either in the form of waste materials or radioactive contamination.

The data sheets describe the status of the stock of wastes present on the site on a given date and, where appropriate, the amount and extent of contamination resulting from former processes involving the use of radionuclides or from former waste management and disposal practices. The sites encompass a large number of types; these may be a nuclear installation, a research center, a mine, a dump, etc., which uses or has used radioactive materials of a total activity more than 1 GBq.

Each data sheet contains administrative and geographic details concerning the site, an overall description of the waste type and, whenever possible, an estimate of the total or specific radioactivity of the inventoried nuclides. The sources are subdivided into the following 12 categories:

Table B-II. Sources of radioactive waste

EDF nuclear power plants	ANDRA's installation and disposal sites
COGEMA mining sites	decommissioned installations
reprocessing plants	dumps
CEA research centers	small producers
nuclear industry plants and companies	distributors of sealed sources
non-nuclear industries	national defense installations

The geographic locations are shown in maps (example of COGEMA mining sites is given in Fig. B-6). The data sheets are grouped by administrative region, however, also available are alphabetical list of site names, names of sites by category, maps of categories with references to the data sheets, geographic map of each region (see, for example, Fig.B-7), and a general map of all sites in France.

As regards the individual data sheets, apart from administrative data, these should contain a brief description of the site history, characterization of the contamination, information on measurements carried out in the past or recently, description of the current status on site, the administrative regimen, and control measures to be taken. As an example, the situation at the site of an older factory utilizing radium as a luminising agent is given in Fig. B-8.

REFERENCE TO ANNEX B-3

[1] AGENCE NATIONALE POUR DECHETS RADIOACTIFS, Inventaire National des Dechets Radioactifs, Edition 1997 (in French; '*National Radioactive Waste Inventory*').

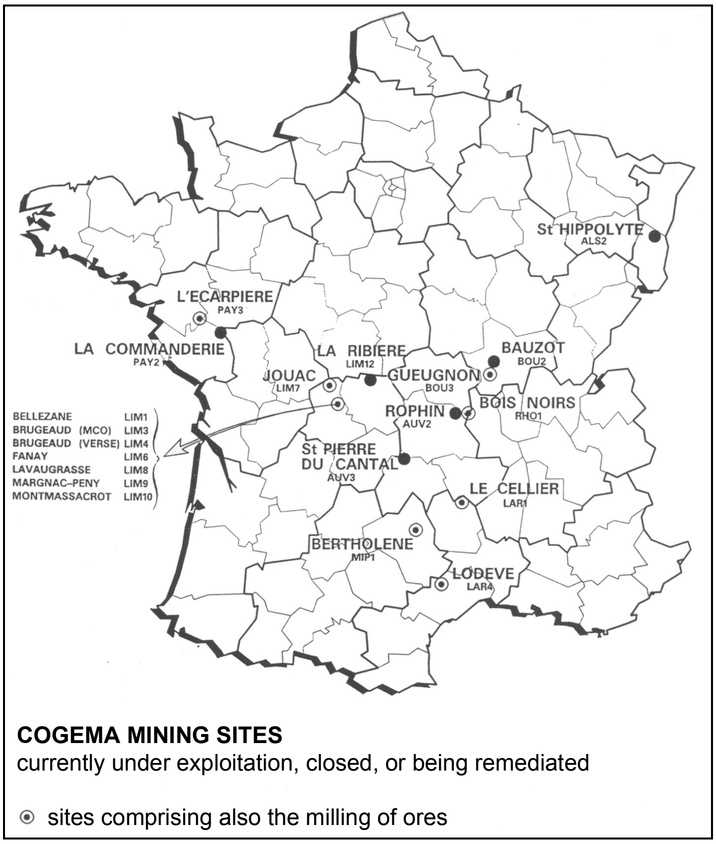


FIG. B-6. COGEMA mining sites in France.

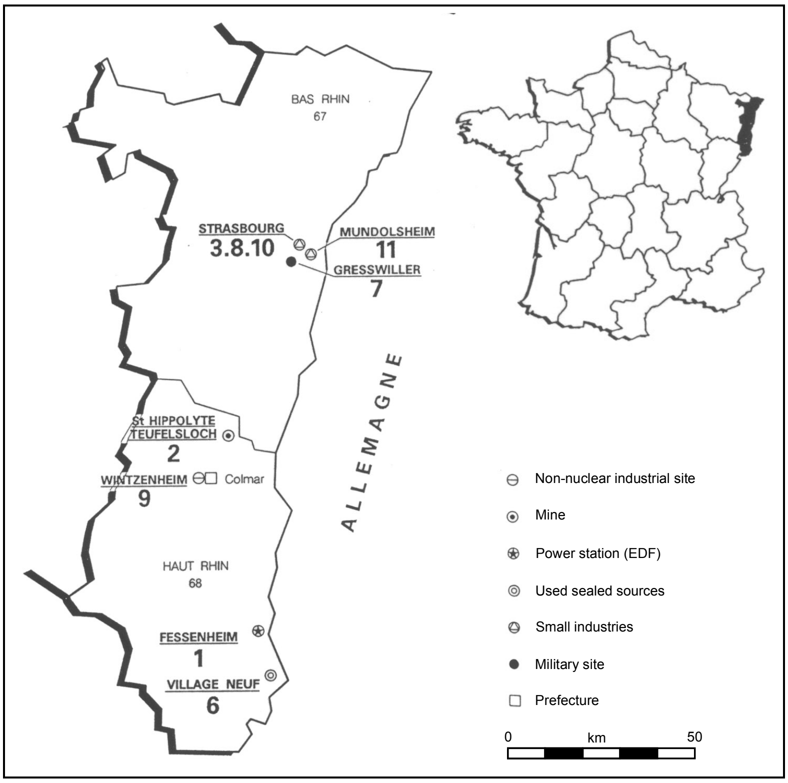


FIG. B-7. Sites with radioactive waste in the Alsace region.

INVENTAIRE NATIONAL DES DECHETS RADIOACTIFS

FICHE N° ALS 9

NOM DU SITE : WINTZENHEIM ANCIENNE USINE JAZ	**CATEGORIE :** INDUSTRIE NON NUCLEAIRE
REGION : ALSACE **PROPRIETAIRE :** SOCIETE SPW **DEPARTEMENT :** HAUT-RHIN **SITUATION :** IMMEDIATEMENT A L'OUEST DE COLMAR	**DESIGNATION :** CONTAMINATION ASSOCIEE A L'UTILISATION DE RADIOELEMENTS DANS L'INDUSTRIE HORLOGERE

DESCRIPTION BREVE :

Les anciens établissements JAZ ont fabriqué jusque dans les années 1960 des montres et des réveils qui utilisaient des peintures radioluminescentes au radium. Cet élément a été remplacé par du Tritium vers 1964 et l'entreprise a cessé sa production vers 1985.
Actuellement le site est réoccupé par une pépinière d'entreprises appartenant à la société SPW.
Un contrôle radiologique de tous les locaux et terrains alentours a été effectué par l'OPRI en octobre 1996.
Aucune contamination radioactive n'a été décelée dans les bâtiments. Par contre, une tache est décelée à l'extérieur d'un des bâtiments.

NATURE DES PRODUITS — SITUATION AU 31/10/96	ACTIVITE GLOBALE	NUCLEIDE(S) MAJEUR(S)
- Tache de contamination à l'extérieur des bâtiments		

REGIME ADMINISTRATIF :

ETAT ACTUEL : Tache de contamination restant à enlever par une entreprise compétente.

MESURES DE SURVEILLANCE :

OBSERVATIONS :

SOURCES D'INFORMATION :
DRIRE / OPRI

DATE DE MISE A JOUR : AVRIL 1997

- 44 -

FIG. B-8. Facsimile of a data sheet of the Witzenheim site in the Alsace region.

Annex B-4. National inventory of radioactive waste in the Russian Federation

In the Russian Federation, the responsibility for management and disposal of non-reactor radioactive wastes is with the state organization *Radon* which is responsible for the whole territory of Russia and which is led by the Moscow *SIA Radon Enterprise*. In order to implement effective control, the Russian territory was subdivided into 16 zones and the respective responsibility was transferred to 16 local *Radon* departments. Each department operates a radioactive waste disposal facility and is responsible for the management and rehabilitation of radioactively contaminated sites.

A radioactive waste inventory based on the Geographical Information System (GIS) was established in a fully computerized form. Subject to registration are the following data:

- name and location of the site;
- geographical and geomorphological characteristics;
- regions of services;
- type and design of the repository;
- date of commissioning;
- storage/disposal capacity, degree of filling;
- annual receipt of waste, total inventory;
- data on radioecological situation in the nearby areas.

Figure B-3-1 provides the principal scheme of GIS. This system allows to obtain any relevant information on the radioactive wastes and associated exposures within the country, together with an overview of geological, hydrological and ecological conditions at the particular site. For example, the module 'Ecology' provides direct information on all radionuclides contained in the 'Zone of Rigid Regime' (ZRR), the 'Sanitary Protection Zone' (SPZ), and the 'Zone of Search' (ZS).

A practical example of an other GIS use is given in Figure B-9. The first screenshot provides basic information on a repository located at a distance of 40 km from Chabarovsk, together with names and addresses of responsible persons and with a brief description of site geology and hydrogeology. The second screenshot shows actual radiation doses around the same repository, and the third one shows effective dose received quarterly by a person (driver) in Volgograd.

A typical layout of the factual situation at and around the Saratov repository is given in Figure B-10.

REFERENCES TO ANNEX B-4

[1] SOBOLEV, I.A. et al., Radiation Anomalies at the Territory of Moscow, Published by Ecomar, Moscow, 1996.
[2] SOBOLEV, I.A., TIKHOMIROV, V.A., Working document, SIA Radon, Moscow.

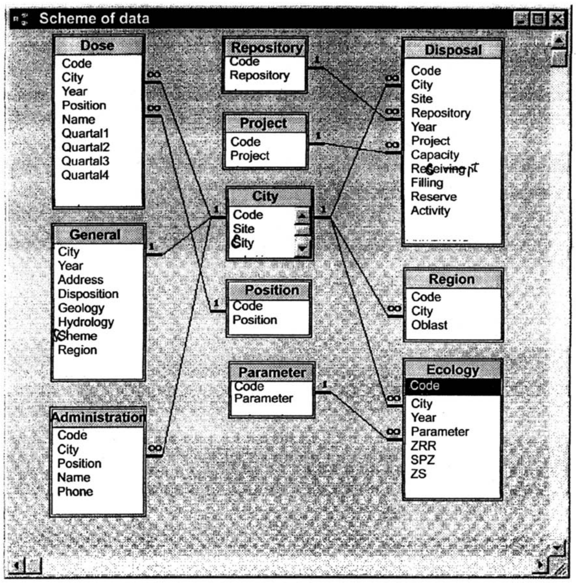


FIG. B-9. The principal scheme of the GIS as designed for the Russian national radioative waste inventory.

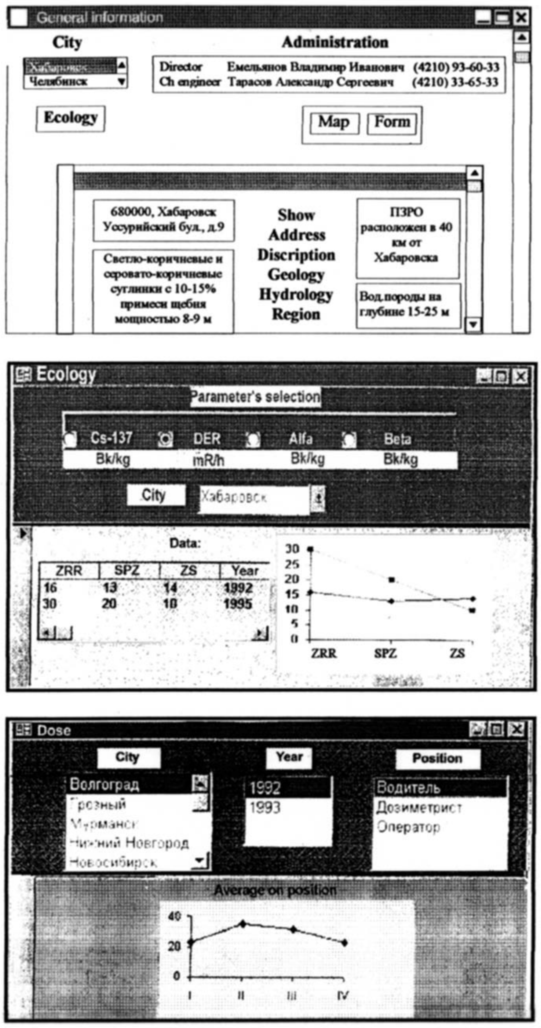


FIG. B-10. Examples for GIS application.

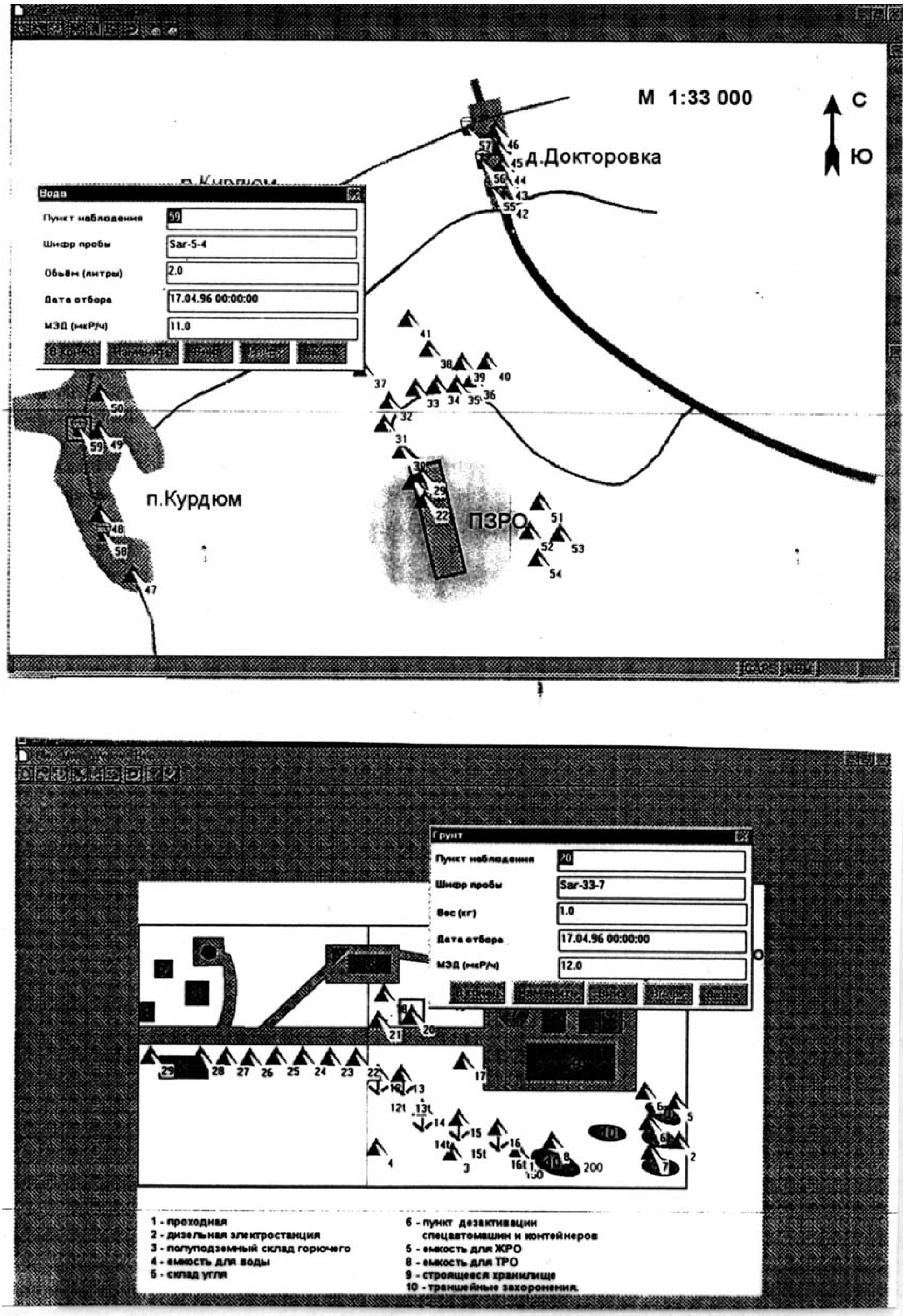


FIG. B-11. GIS representation of the conditions around the Saratov radioactive waste repository.

Annex B-5

Russian Federation: The RADLEG database

1. INTRODUCTION

The International Science and Technology Center (ISTC) [1], located in Moscow, promotes the nonproliferation of weapons technology of mass destruction. The Center coordinates the efforts of numerous governments, international organizations, and private sector industries to provide weapons scientists from Commonwealth of Independent States (CIS) countries with opportunities to redirect their talents to peaceful science.

The objective of ISTC Project No. 245 “RADLEG” [2], which was launched in 1995, is to collect data and to create a publicly accessible database on the radiation legacy within the CIS [3]. A considerable number of institutions participated in the project or acted as consultants (Table B-III). The project management is provided by VNIICHT.

Table B-III. Organisations participating in the RADLEG project

NAME	ACRONYM
Participants	
Ministry of Russian Federation for Atomic Energy	MinAtom
All-Russian Scientific Research Institute for Inorganic Materials	VNIINM
Mining-Chemical Combine	MCC
Radium Institute	NPO “RI”
All-Russian Scientific Research and Designing Institute for Production Engineering	VNIPIPT
All-Russian Scientific Research Institute for Nuclear Power Plants Operation	VNIIAES
Russian Academy of Sciences	RAS
Central Economic-Mathematical Institute of the RAS	TSEMI
Institute of the Geology of Ore Deposits of the RAS	IGEM
Institute of Global Climate and Ecology	IGKE
Institute of Geochemistry and Analytical Chemistry of the RAS	GEOKHI
Nuclear Safety Institute of the RAS	IBRAE
Russian Research Center “Kurchatov Institute”	RRC “KI”
Russian Ministry of Defense	MO RF
Scientific & Industrial Company Radon	“Radon”
Ministry for Environmental Protection and Natural Resources of Russian Federation	MinPriroda
State Institute for Applied Ecology	GIPE
Moscow State University	MGU
Interindustrial Innovational Research Association “Technological Risk and Human Safety”	IIRA “INTEST”
Consultants	
All-Russian Scientific Research Institute of Experimental Physics	VNIIEF
All-Russian Scientific Research Institute of Technical Physics	VNIITF
Industrial concern Mayak	"Mayak"
Siberian Chemical Combine	SCC

The RADLEG database [4] contains systematized information on sources of radioactive contamination in various regions of Russia and some other CIS countries, which is required for risk evaluation, planning, and the development of concepts and strategies for remediation and sustainable development of the regions.

Most of the pertinent data are spatially defined, that is they relate to objects of the civilian and nuclear fuel cycle and to contaminated territories that have specific geographic coordinates. For this reason a database was created that is based on a geoinformation system (GIS) and that allows a range of sophisticated analyses and presentations of the problem of the radiation legacy.

2. DATABASE DESIGN

A simple operational prototype of the database has been generated on the basis of the database management system Access™ developed by Microsoft. MS Access™ allows to create screen forms, reports, queries on the basis of the information loaded into the database. The information was loaded into the database by way of import from files in DBF format provided by the participating organisations. At the present the RADLEG database contains information prepared by 12 organizations, taking part in the Project (see Table B-III).

The concept of the logical data structure of the RADLEG database has been developed on the basis of recommendations of the Project's participants given at the Workshop on May 25–26, 1995. The structure of the set of indices of the State Register of sites and objects of mining, storage and disposal of radioactive materials, and of sources of ionizing radiation on the territory of the Russian Federation was also taken into consideration [5].

The currently accepted version of the database worksheet includes seven major data blocks (Table B-IV). The database logical structure includes about 300 indices, and the number can be easily changed, either increased or reduced.

Eventual correction of the database logical structure is provided for, as well as for including of additional data blocks into the structure. For instance, the development of the data block no. 400 "Geological data" recently has been completed with IGEM of the RAS as the leading organization.

Table B-IV. The RADLEG database: Structure (main information blocks)

Block No.	Description	No. of fields and subfields
100	General information	18
200	Physical, chemical and technical characteristics of radioactive materials, isolated from the environment by man-made or natural barriers	110
300	Physical, chemical and technical characteristics of radioactive materials in the environment	84
400	Geological data	72
500	Institutional data	
600	Social information	
700	Doses and risks	
900	Data sources	13

Table B-V. The RADLEG database: Classification of objects

CLASS NO.	CLASS DESCRIPTION
0100	**In situ leaching sites (uranium mining)**
0200	**Surface radioactive waste storage facilities**
0210	Ore and rock dumps
0220	Tailings of any type
0230	Water reservoirs of any types
0240	Storehouses of any types
0250	Burials of any types
0260	Radwaste interim storage sites
0270	Coastal radwaste storage facilities
0300	**Deep underground liquid radwaste disposal sites**
0400	**Nuclear reactors and critical facilities**
0410	Nuclear reactors
0420	Critical facilities
0500	**Nuclear explosions**
0510	Peaceful nuclear explosions
0520	Nuclear weapons tests
0521	underground
0522	on-surface
0523	above-water
0524	air
0525	space
0600	**Radioactive air releases**
0610	From nuclear facilities' routine operation
0620	As a result of nuclear explosions
0630	As a result of emergencies
0700	**Radioactive discharges into open water systems**
0710	From nuclear facilities' routine operation
0720	As a result of emergencies
0800	**Contaminated land**
0810	From nuclear facilities' routine operation
0820	As a result of nuclear explosions
0830	As a result of emergencies
0900	**Radioactive sea-dumping**
0910	Solid radioactive waste in containers
0920	Ships with solid radioactive waste
0930	Reactor compartments
0940	Ships with reactor compartments

The main entity within the database system is the object, meaning that each record in the database contains pertains to the description of a particular object. Two categories of objects are distinguished: man-made (engineered) and natural ones. The physical, chemical and technical characteristics of man-made objects are given in data block 200, those of natural objects in data block 300. The database containes descriptions, for instance, of such objects as nuclear research reactors or ‘critical’ test facilities, radioactive waste storage facilities, ponds for collection of liquid radioactive wastes at spent nuclear fuel reprocessing plants, a nuclear test sites, natural objects, e.g. fields, forests, lakes, contaminated with radionuclides, etc. [6]

Indices, describing the physical, chemical and technical characteristics of objects in the database are unified, but a set of the indices for a certain type of objects is individual.

Objects are divided into nine classes and each class may include a number of sub-classes. A special four-digit code is corresponding to each object’s class or sub-class. The classification of objects in the RADLEG database is detailed in Table B-V.

The records in the existing version of the RADLEG database are divided into 13 subject sectors with each of them having its own four-digit code, corresponding to the main sectors of the CSI radiation legacy investigations (see Table B-VI). Each sector of the database includes descriptions of enterprises, institutions or test sites that are also coded in accordance with the RADLEG classifier of enterprises. For instance, nuclear power plants have code numbers from 0101 (Balakovo NPP) to 0116 (South-Ukrainian NPP), research institutes, experimental production works, research reactors etc. have numbers from 0301 (RRC “Kurchatov Institute”) to 0331 (Sukhum Physical & Technical Institute), and so on.

The correlations within the database between the sectors and object types (classes, sub-classes) are shown in Table B-VII.

An outline of the RADLEG database operation, data management and interface development is presented in Fig. B-12.

Table B-VI. RADLEG database: Main sectors of the CIS radiation legacy

Sector No.	Sector Description
0100	Nuclear power plants
0200	Coastal radwaste facilities of the ministry of defense, sea-dumped objects, marine nuclear power facilities and service enterprises
0300	Research institutions, experimental production works, research nuclear reactors and nuclear research centers
0400	Nuclear weapons tests
0500	Peaceful nuclear explosions
0600	Storage and processing of non-reactor radwaste and sources of ionizing radiation
1100	Prospecting, mining, enrichment and processing of uranium ores
1200	UF_6 production and uranium isotopic enrichment
1300	Nuclear fuel manufacturing
1400	Radiochemical reprocessing of spent nuclear fuel
1500	Nuclear materials production
1700	Chernobyl 30-km zone
1800	Power reactor facilities

Table B-VII. RADLEG project database: Correlation between the sectors of the CIS radiation legacy and the main object types

	SECTORS \ OBJECTS	0100 Underground leaching sites	0200 On-surface radwaste storage facilities	0300 Deep liquid radwaste disposal sites	0400 Nuclear research reactors and critical facilities	0500 Nuclear explosions	0600 Radioactive air releases	0700 Radioactive discharges into open water system	0800 Contaminated lands	0900 Radioactive sea-dumpings
0100	Nuclear power plants		■				■	■	■	
0200	Coastal radwaste storage facilities of the ministry of defense, sea-dumped objects		■							■
0300	Research institutions, experimental production works, research reactors and nuclear research centers		■	■	■		■	■		
0400	Nuclear weapons tests					■			■	
0500	Peaceful nuclear explosions					■				
0600	Storage and processing of non-reactor radwaste and spent sources of ionizing radiation	■	■							
1100	Prospecting, mining, enrichment and processing of uranium ores		■				■	■	■	
1200	UF_6 production and uranium isotopic enrichment		■	■			■	■	■	
1300	Nuclear fuel manufacturing		■				■	■	■	
1400	Radiochemical reprocessing of spent nuclear fuel		■	■			■	■	■	
1500	Nuclear materials production		■				■	■	■	
1700	Chernobyl 30 km zone		■						■	
1800	Power reactor facilities		■							

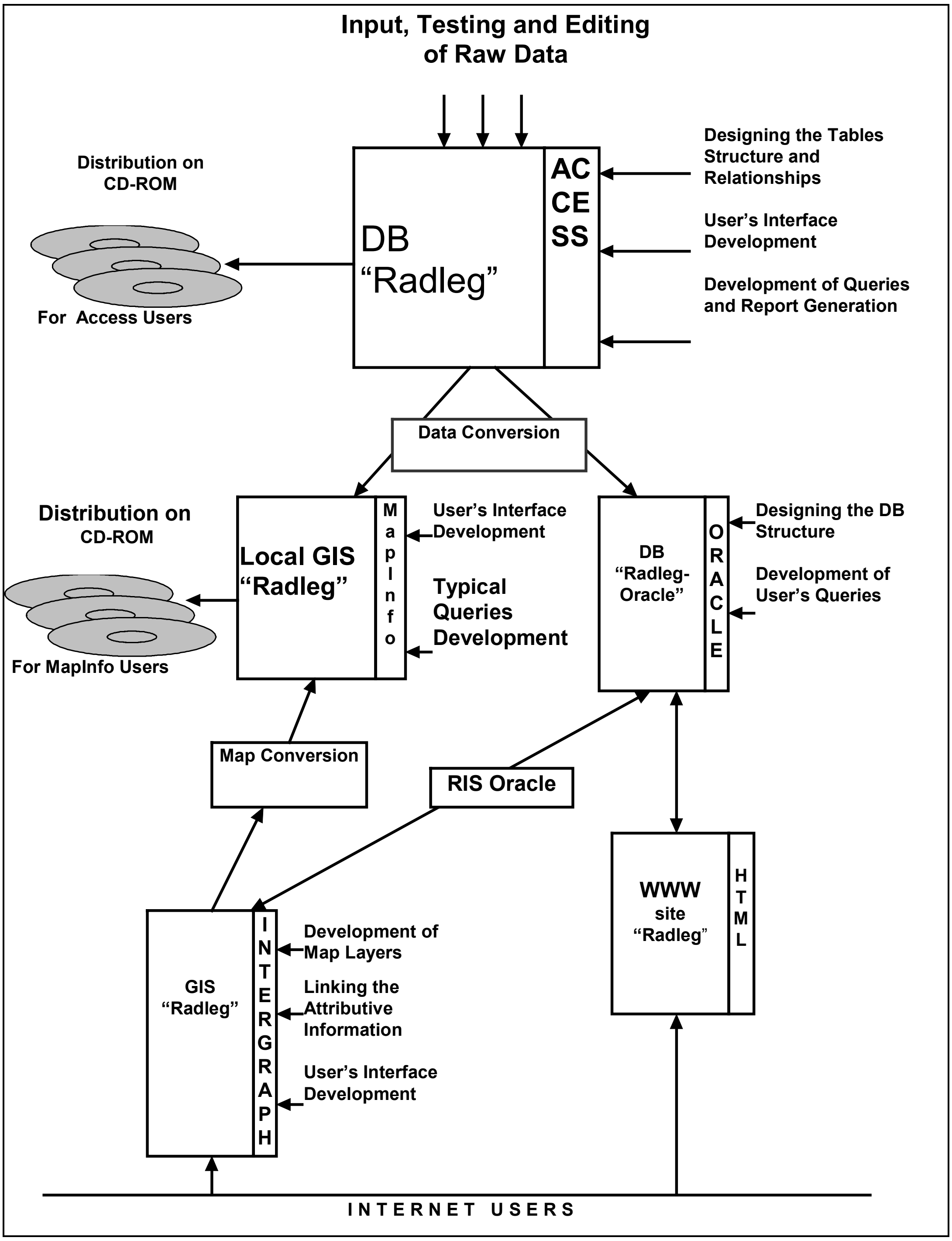


FIG. B-12. Outline of the RADLEG DB structure, operation and strategy of development.

When designing the database screen forms, the data were conventionally divided into the following four categories:

- Enterprises;
- Objects;
- Events;
- Accidents.

The category EVENTS gives information about dumpings, nuclear explosions, contaminated lands, releases and discharges of radioactive substances. This category provides the option of selecting enterprises according to the classification type of events. In addition, in the right hand corner of the screen (box EVENTS) data on specific types of events are displayed. Examples of screen forms for the category EVENTS are shown in Figs. B-13 and B-14.

Russian plans for activities on environmental protection, remediation and sustainable development foresee the preservation of the quality of fresh water, measures for the safe and ecologically sound management of toxic and radioactive wastes, remediation of radioactive contamination on Russian territories, and the ecologically sustainable development of the regions of Russia. Implementation of the plans is based on up-to-date technologies and reliable initial environmental information. The RADLEG database will provide this information.

Table B-VIII. RADLEG project database: Sources of data on CIS radiation legacy

Code	DATA SOURCES / SECTORS	VNIICHT	VNIPIPT	VNIIAES	Radium Institute	Kurchatov Institute	RF Ministry of Defense	IGEM	GEOCHI	IBRAE	IGKE	Radon	GIPE
0100	Nuclear power plants			■					■	■	■		
0200	Coastal radwaste storage facilities of the ministry of defense, sea-dumped objects				■	■	■						
0300	Research institutions, experimental production works, research reactors and nuclear research centers	■	■			■							
0400	Nuclear weapons tests				■						■		
0500	Peaceful nuclear explosions		■										■
0600	Storage and processing of non-reactor radwaste and spent sources of ionizing radiation											■	
1100	Prospecting, mining, enrichment and processing of uranium ores	■											
1200	UF_6 production and uranium isotopic enrichment	■											
1300	Nuclear fuel manufacturing	■											
1400	Radiochemical reprocessing of spent nuclear fuel	■	■		■			■					
1500	Nuclear materials production	■	■										
1700	Chernobyl 30 km zone	■				■							
1800	Power reactor facilities	■											

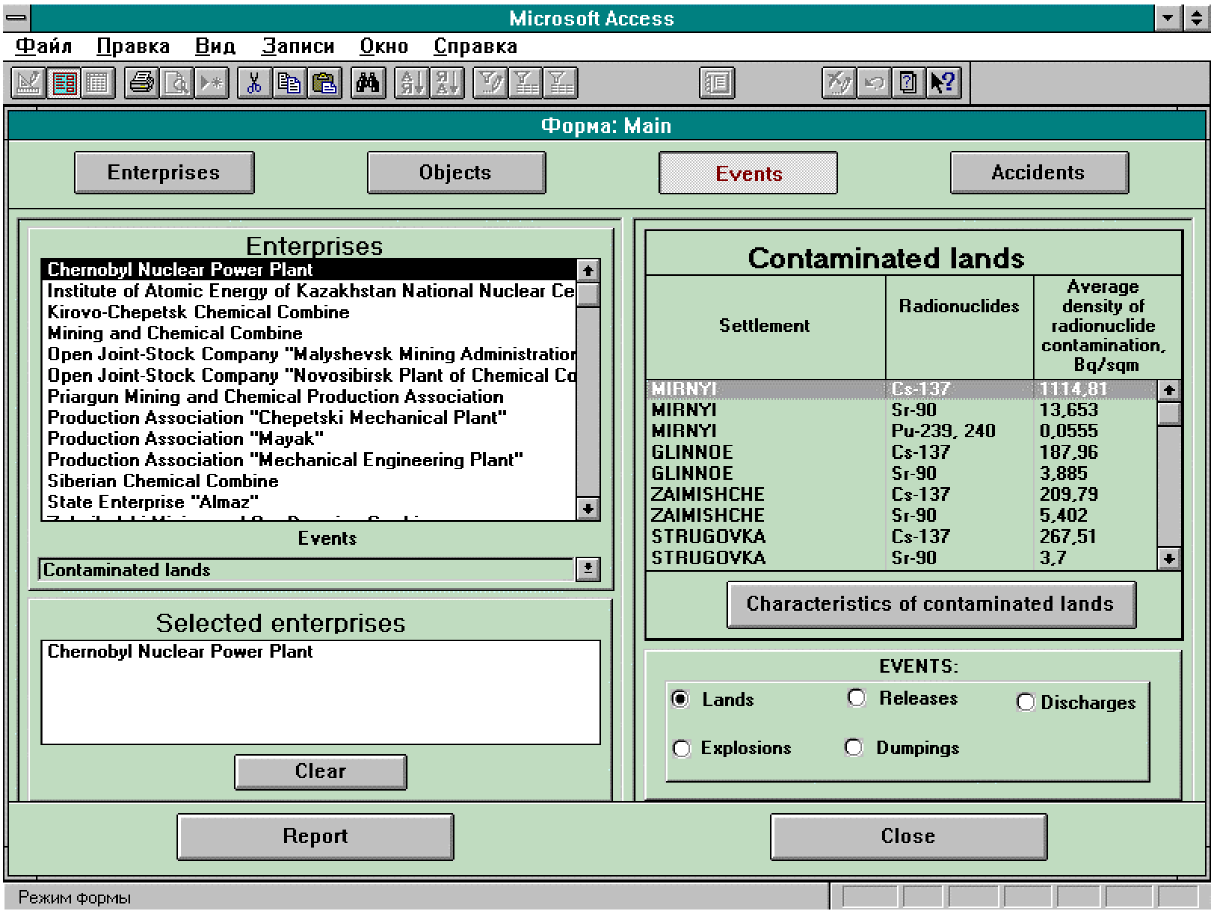


FIG. B-13. Screen shot "Lands contaminated by Chernobyl".

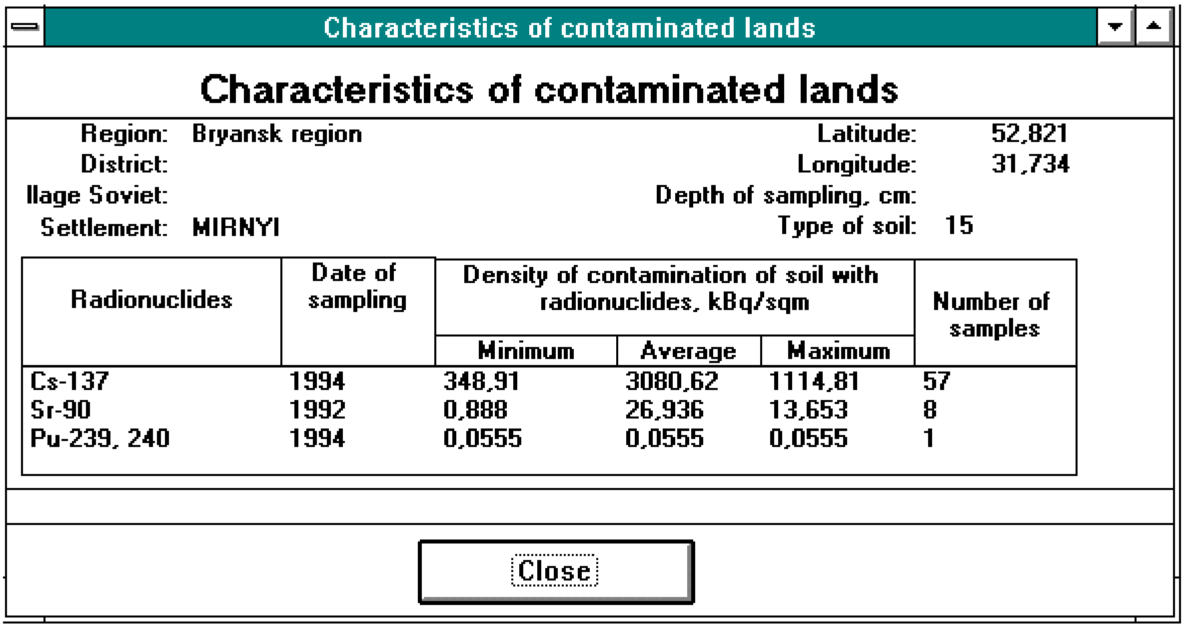


FIG. B-14. Screen shot "Characteristics of lands contaminated by Chernobyl"

REFERENCES TO ANNEX B-5

[1] http://www.istc.ru/ (21/11/00).

[2] EGOROV, N.N., et al., "Development of a sophisticated compute-based data system for evaluation of the radiation legacy of the former USSR and setting priorities on remediation and prevention policy. Phase 2, Project # 245-2B. Development of a Public Accessible Database", Consolidated Report (February–March 1999), Moscow, VNIICHT (1999).

[3] BRYKIN, S.N., MARKOVSKI, V.V., STEPANOV, A.C., YAKUSHEV, S.A., "Development of a public accessible database", Radiation Legacy in the CIS (Proc. Int. Seminar on ISTC Projects, March 8-9, 1999, Brussels, Belgium, European Commission DG-XII (1999) 21–22.

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