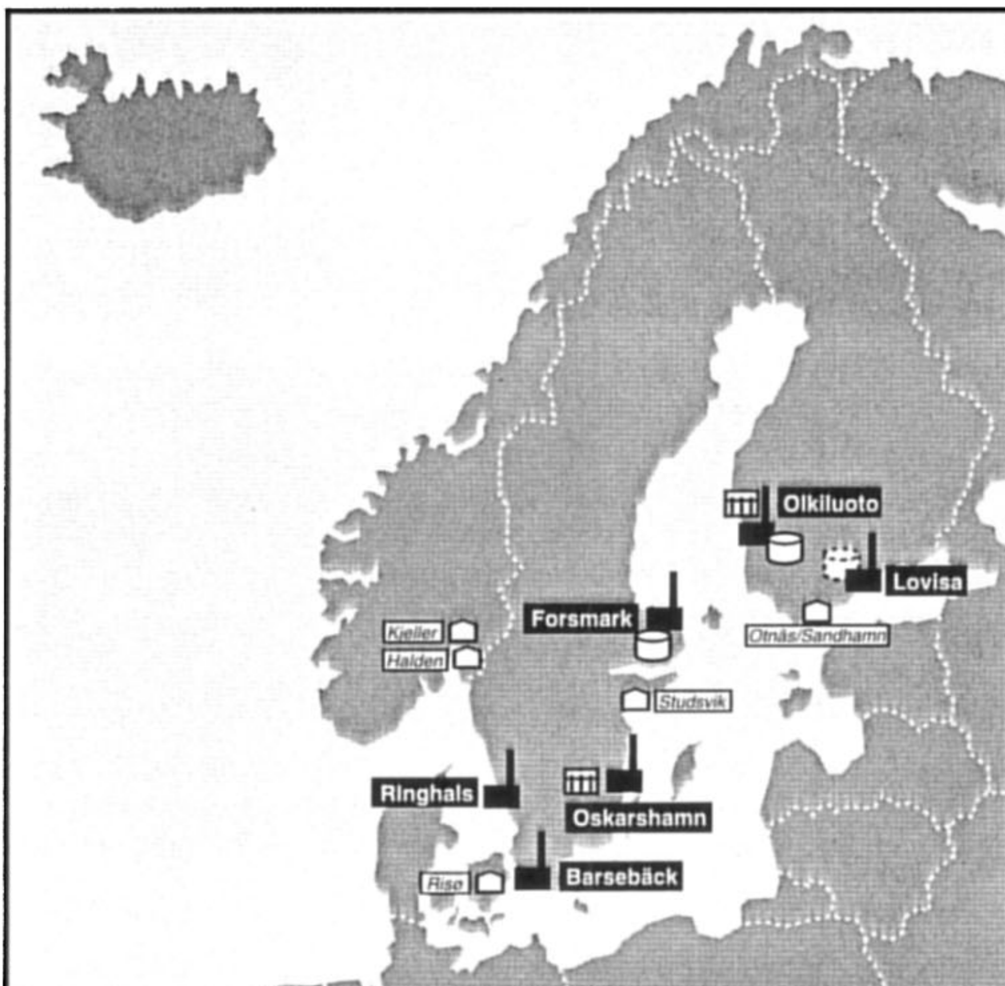
THE NORDIC WASTE PROGRAMME

1990-93



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THE NORDIC PROGRAME ON WASTE AND DECOMMISSIONING (KAN)

1990-93

Summary
by the KAN-coordinator
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March 1994

The Nordic Nuclear Waste and Decommissioning programme 1990 - 1993

The present document is a short summary of the 1990-1993 NKS nuclear waste programme. The programme includes 5 projects:

> Criteria and procedures for the clearance of radioactive material (the KAN- 1.1 project)
>
> Experience from decommissioning of a uranium reprocessing pilot plant (the KAN-1.2 project)
>
> Conservation and retrieval of information (the KAN-1.3 project)
>
> Cleanup of large radioactive contaminated areas and disposal of the generated waste (the KAN-2 project)
>
> Climatological processes of importance for the long term stability of a repository for radioactive waste (the KAN-3 project)

Nordic project work in the waste field

There is radioactive waste, both from nuclear and non-nuclear activities, in all the Nordic countries. Most of the nuclear waste originates from the 16 nuclear power reactors in Finland and Sweden, but some nuclear waste from research reactors also exists in Denmark and Norway.

In total there is an extensive research and development effort related to radioactive waste in the Nordic countries. Over the years several joint Nordic programmes have dealt with questions of common interest in this field. To-day, the main development takes place in Finland and Sweden in order to develop systems for the final disposal of spent nuclear fuel and other long lived waste. Minor research and development efforts in Denmark and Norway are focussed on low and medium level waste. In Iceland only very small waste amounts are generated.

The national programmes are complemented by joint safety oriented projects within the framework of the Nordic Nuclear Safety Research cooperation (NKS). The rationale for the Nordic Programme is to promote a common approach and understanding of nuclear safety issues. Joint project work in the framework of the NKS is a useful tool to transfer experiences and create personal relations between individuals in different Nordic authorities and research organizations.

An overview of the KAN project results

In assessing nuclear waste safety, both long term and short term aspects need to be considered. For the development of a system for the final disposal of spent nuclear fuel, the most challenging task is to develop a sufficient understanding of the long term safety of a potential repository. Two of the NKS-projects are directly relevant for the long term safety of a deep geological repository, whereas the other projects mainly concern issues in managing nuclear waste today.

* Information about repositories and their contents must be conserved so that it can be easily retrieved. This will reduce the likelihood of human intrusion or other human actions that potentially can disrupt the repository. The KAN-1.3 studies deal with available information and how to preserve it. Archive safety as well as the expected durability of different archive media is explored.

* In the long term the present day climate will change significantly. Any long term prediction of the performance of a repository must take this into account. An important part of the KAN-3 project has been to assemble field evidence, such as historic data indicating how shore lines have been displaced, and other effects of past glaciations. The potential impact of a future glaciation on a repository is also explored in this project.

* An unlikely accident at a nuclear power plant could result in deposition of radioactive elements in the environment so that cleanup becomes necessary. This may result in a considerable amount of waste, both in terms of volume and activity content. In the KAN-2 project waste volumes and activities in different environments are estimated. Experiments have been performed with soil removal, and with cement solidification, and cost-benefit analyses are developed for use in emergency planning.

* Clearance of radioactive materials from regulatory control may reduce waste volumes that must otherwise be handled as radioactive, especially in conjunction with decommissioning. In the KAN-1.1 project the essential aspects of the clearance problems are dealt with such as definitions, radiological assessments, and monitoring. Guidance is put forward on the preparation of a clearance application.

* Eventually all nuclear installations in the Nordic countries will have to be decommissioned. Experiences gained from decommissioning is thus essential for planning of future work and for estimating the costs for such activities. In the KAN-1.2 project, the decommissioning of a pilot reprocessing plant is documented and the practical experiences recorded. The profitability of decontamination versus direct disposal of the equipment is evaluated.

Criteria and procedures for the clearance of radioactive materials (KAN-1.1)

■ Objectives

If a certain material is classified as radioactive, e.g. material which has entered the controlled area of a nuclear power plant, it has to be managed in accordance with complex and often expensive procedures. This means that there is a substantial incentive to reclassify the material as non-radioactive, i.e. to release it from regulatory control.

This project contains guidance and background information on clearance of radioactive material with so low activity that it is of no concern from the radiation point of view. The main target groups of the study are the waste producers who make applications for clearance of radioactive materials, and the competent authorities who review such applications and prepare rules and guides on this subject.

■ Basic principles

The radiation protection principles for the clearance of radioactive materials have been established by the international organizations IAEA, OECD/NEA and EC. Determination of the activity constraints, i.e. what is the maximum allowed activity in a material, is underway in the international organizations and some recommendations have already been made.

The discussion of radiation protection principles for release of radioactive materials is based on the International Atomic Energy Agency's Safety Series No 89. In the project only *clearance* from regulatory control is discussed. Clearance implies removal of restrictions from materials which have been subject to requirements of regulatory control. The term *exemption*, which is not further treated in the project, implies that the material is excluded as a whole from the regulatory regime. Exemption is only practiced for small scale use of radioactive sources such as calibration sources or consumer products.

Unconditional clearance implies complete removal of all controls. The clearance levels must be based on generic scenarios where usually rather pessimistic assumptions are used. Consequently, the clearance levels tend to be low (only materials with very low activity content may be cleared unconditionally). On the other hand, if the future use of the material is known, only specific scenarios need to be analyzed, which usually results in higher clearance levels for such *conditional* clearance. However, the conditional clearance levels must be revised if there is a significant change in the use of the cleared material.

■ Potential types and quantities of materials to be cleared

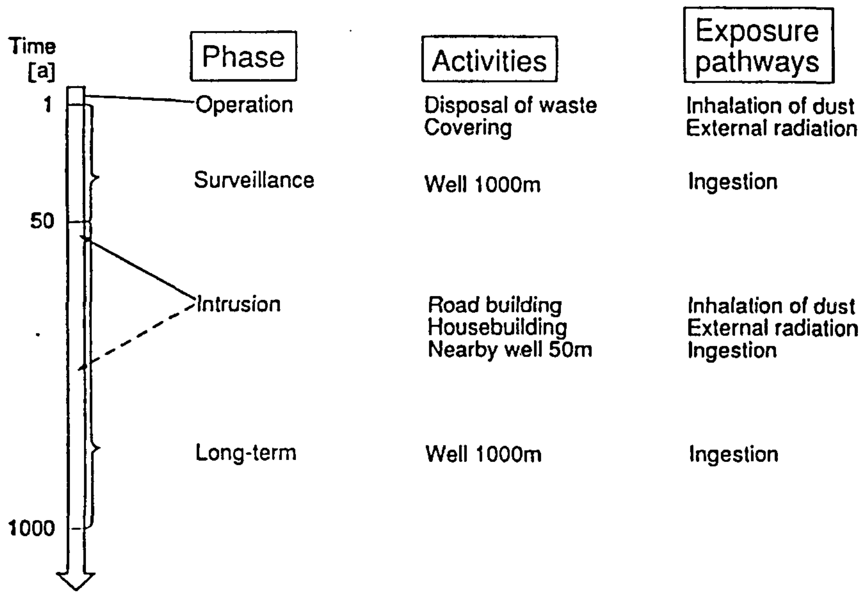
Examples of materials that might be cleared from regulatory control are:

- part of the nuclear waste generated during the operation of nuclear power plants such as oil, scrap metal and trash.
- part of the waste resulting from the decommissioning of nuclear power plants such as concrete, scrap steel, other metals, insulation materials, trash and sand. The volume (about 30,000 m3 concrete per reactor) is about three times larger than the volume of the waste that needs to be disposed in a repository.
- part of the waste resulting from the decommissioning of other nuclear installations such as research reactors, hot cell facilities and waste treatment plants. Such installations exist in all Nordic countries. The waste is similar to that from power reactors, but the volume is smaller.
- most of the waste resulting from the use of radioisotopes in hospitals, industries and research institutes.

■ Radiological assessments

In order to determine the proper clearance level it is necessary to perform a radiological assessment where the future fate of the material is taken into account. The report discusses results from various analyses including studies supported by different Nordic organizations.

Several *landfill disposal* pathways that may cause radiation doses to humans are considered. Scenarios include fire, groundwater migration, a road through the site, and residence in a house located over the site. For the different radionuclides considered, the resulting doses range from 0.1 to 300 μSv/a for an activity content of 1 Bq/g of a radionuclide present in the material.



An example of exposure pathways for landfill disposal /15/

For the case of *incineration*, doses to operators and residentials are calculated. The doses range from 0.1 to 50 μSv/a for an activity content of 1 Bq/g. Incineration also results in a collective dose, but the dose to the operator of the incineration plant is more limiting. The ash may need to be treated as radioactive waste if it cannot be directed to landfill disposal.

For *recycling of metals* the analysis deals with several phases such as storage and pretreatment, melting and manufacturing. The use of products as well as use or disposal of byproducts are also dealt with. The resulting doses range from 0.1 to 1000 μSv/a for 1 Bq/g for individual radionuclides. The collective dose may be a concern.

For *reuse of components or buildings* the resulting doses range from 10 to 100 μSv/a for a surface activity of 1 Bq/cm^{-2} of the dismantled material.

In conclusion, it appears that the doses are highly nuclide and scenario dependent. For inhalation the most restrictive nuclides are long lived alpha emitters (e.g. Pu- 239, Am-241). For external exposure the restrictive nuclides are strong gamma emitters (e.g. Co-60, Cs-137), whereas in water and food the beta emitters (e.g. Sr-90) may be most restrictive.

It is impractical to strive for universal clearance that would cover all waste types and all potential exposure scenarios. Unconditional clearance levels are often too low with respect to actual concentrations or with respect to the possibilities to measure the activity. Consequently, conditional clearance is an attractive option, in particular for large volumes of nuclear waste.

■ Activity monitoring

A prerequisite for clearance is that compliance with clearance levels has been shown with sufficient reliability. For this purpose, a carefully planned monitoring programme is needed. It would normally consist of two phases: a preliminary survey, followed by monitoring for clearance.

In principle, methods and instrumentation are available for monitoring all kinds of wastes and nuclide compositions, but when it comes to »difficult-to-measure« nuclides (pure beta or alpha emitters) it is usually sufficient to estimate them by scaling from the level of a directly measurable gamma emitter. Evidently it is necessary to ensure that the scaling ratio leads to overestimation of the nuclide in question, and it is important to keep adequate control of nuclide composition in material that may be cleared.

■ Regulatory control

There is a minimum of information that needs to be included when an application for clearance is submitted to the competent authority. In all cases a description of the origin, characteristics and likely radionuclide composition of the material and the methods to be used for determination of activity is needed.

An application for conditional clearance needs atonal information, such as a general description of methods to be used for recycling or disposing the material as well as an analysis of radiation exposure arising from its further use.

All the clearance procedures, including proper documentation, should be performed in the framework of a control system, set up in accordance with recognized quality assurance requirements.

Experience from decommissioning of a uranium reprocessing pilot plant (KAN-1.2)

■ Background

A pilot plant for reprocessing of irradiated fuel at the Institutt for energiteknik (IFE), Kjeller in Norway had been in operation from 1961 to 1968. 1200 kg of uranium was processed and plutonium and fission products were separated by means of liquid-liquid extraction. Totally, the plant comprised a tubing system of more than 6000 meters and a total of 50 tanks, evaporators and extraction columns. The plant was shut down and partly decontaminated in 1968, but decommissioning proper was not carried out until 1982, and then again during the period 1989 to 1993. The objective of this project was to draw conclusions from this latter decommissioning effort so that the experience is available in the future.

■ Radiation protection during decommissioning

Before decommissioning and after decontamination the general radiation level was 0.15-0.3 mSv/h, with some more active areas with dose rates up to about 10 mSv/h. On the floor the contamination was below detection level, but at certain locations beta levels up to 5000 Bq/cm^2 and alpha levels up to 500 Bq/cm^2 were detected with an average activity a factor of twenty lower.

From a radiological point of view the overruling aspect in the dismantling work was to prevent contamination to spread to clean areas. This was achieved by issuing detailed specific working instructions. The radiation protection of the workers aimed at reducing the exposure to external radiation and preventing the intake of radioactive materials. For the latter there was concern about the risk of inhalation, therefore some operations were performed with dust masks or air stream helmets. No or very small exposures were registered.

■ Proper decommissioning procedures

In decommissioning, the first step is to accept all the safety and protection procedures. The detailed planning can then be carried out in accordance with these procedures. Several practical recommendations are provided, for example on organization, working conditions, daily clearing and washing of the working area, ventilation, and packaging of waste. It is a great advantage if people from the original operation are available at the time of dismantling.

Working conditions and social conditions are of special importance during the decommissioning period. Dismantling may be understood by the crew as a degenerating operation. In addition it is a tough and physically complicated work. A positive argumentation including true support from the management is therefore needed.

■ Tools used in the decommissioning work

Most of the dismantling of equipment could be carried out with standard tools. In addition a range of special tools needed adjustment, including »hands-off« cutting tools, dismantling tools and lifting aids. The work has resulted in ample experience, documented in the report by figures and photographs. Examples are the use of a clamp cut-device, hydraulic cable cutter, plasma arc cutting, angle grinder, electric saw, riveting punch/chisel hammer, bayonet saw, explosive drilling clamp as well as other tools.

■ Decommissioning costs

The decommissioning cost was NOK 6 million. Out of this the cost for tools was 0.6 MNOK and MNOK 0.6 for waste treatment. The cost may seem high but should be viewed in relation to the total investment and operational cost of MNOK 122 (1992 value, roughly equal to 20 million USD). The cost was also influenced by a discontinuous working procedure.

■ Decontamination and waste treatment

Decommissioning involves treating considerable quantities of radioactive material. In order to keep the waste volume low the principal options are to decontaminate the equipment so that it can be cleared from regulatory control, or to pack the waste as tight as possible. Both these options were used.

For pipelines and vessels which could not be re-used and consequently only had the scrap metal value, it was found that chemical decontamination was unprofitable compared to cutting and direct packing into waste containers. For some items like lead shielding blocks and concrete shielding blocks, which had sufficient re-use value, decontamination was profitable.

Different means of chemical decontamination were tried. In general it is possible to decontaminate all metal parts using different chemicals and time consuming operations, but costs, secondary waste volumes and final disposal must be borne in mind. Also decontamination followed by activity monitoring of internal parts of process equipment and pipes was tried, but not on a large scale as it was found that decontamination was unprofitable compared to accepting the equipment as solid waste.

One main objective of the waste treatment was to reduce the volume. This was achieved by selecting a proper geometrical form of the waste package (boxes instead of drums) and by making effective use of the package volume by packing smaller items inside larger ones. It was also noted that use of smaller containers requires more cuttings of the waste material and thus longer working hours.

In general terms it is concluded that one should not start decontamination before a precise analysis has been made of the sequence of decontamination steps, and before the generation of secondary waste volume has been ascertained in a realistic way.

In the period between termination of the operational phase and the start of decommissioning it is essential to maintain a staff which is given the responsibility of the plant, its safety, and the conservation of the archives. Important tasks are also to prevent uncontrolled removal of equipment and avoid spread of contamination.

Conservation and retrieval of information (KAN 1.3)

■ Objectives

High-level waste from nuclear power reactors will remain radioactive for thousands of years. Certain information about the waste must be kept for very long time because future generations may come into contact with the waste, intentionally or unintentionally. Present day waste management would benefit from an early identification of the information that should be kept and how it should be conserved.

The objective of the KAN-1.3 project is to establish a common Nordic view on the need for conservation of information about waste repositories by investigating:

- what type of information should be stored
- in what form it should be kept
- the quality of the information, as regards both type and form
- the problem of future retrieval of information, even after very long periods of time

■ Scientific Aspects on how to preserve information over long times

The problem of information conservation has two basic solutions. The first is simply to trust that the present and coming generations will pass on the relevant information to the next generation. The second solution is to rely on achieves and markers rather than humans to pass on the information. Both solutions have flaws. A flaw with the first solution is that information transfer from generation to generation may in fact be broken or distorted. A problem with the second solution is the durability of achieves and the possibility that the information in the achieves may be misinterpreted in the future due to substantial cultural changes in society.

Therefore, a hybrid solution may be the preferred option. Such a solution implies that the information is allowed to evolve as culture changes, but the original information is kept in an archive as a reference.

■ Present information about nuclear waste

A part of the project has been to explore the amount and kind of information that exists today about existing waste facilities such as the repositories for reactor waste (low and intermediate waste) in Sweden (SFR) and Finland (VLJ) as well as the interim storages for spent nuclear fuel in Sweden (CLAB) and Finland (KPA). There are records on the waste and on the spent fuel. The exploration has resulted in a first attempt to prioritize which information should be kept in the future.

■ Information Management

The future need for information varies with time (radioactive decay) and according to the information receiver. For example, an advertent intruder (i.e. someone who knows about the repository and its content such as a repair force) needs much more information than a community that just wishes to avoid intrusion.

The most valuable information includes the geographical location of the repository, the waste characteristics, the design of the repository and the background information that went into the final safety assessment. The total amount of information is still relatively limited, which means that there is presently no real incentive to make any extensive culling.

It is recommended that at the outset basically all information is stored in an archive. This information is called the Primary Information set. A Second Level of Information set containing copies of the Primary information and information on where to find the Primary Information should be put in a regional archive. To ensure redundancy even a Third Level of Information Set could be considered.

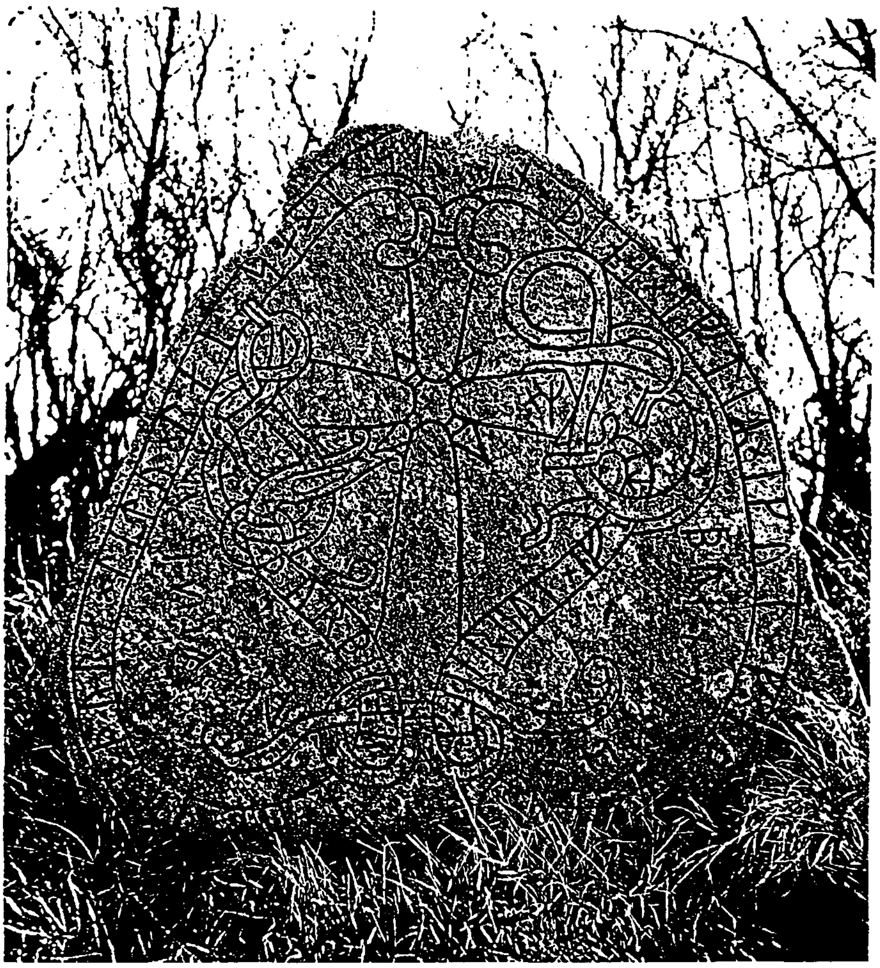
■ Systems for conservation and retrieval of information

A significant part of the project has been to discuss whether the information about the repository, at the time when it may be needed, will be available in some form, whether it can be retrieved and if it can be understood. Achieves with information about nuclear waste repositories will probably be given special attention in the future, but the present society will have to weigh the cost against effect. Thus a system of general recommendations is provided rather than detailed suggestions on how to ensure information conservation.

Three strategies: achieves, markers and information by continuing processes in society are discussed.

Potential threats to achieves have been explored by studying the fate of the Vatican achieves and the German achieves during the 20th century. Modern copying techniques may improve the safety of the conservation by creating duplicate versions of the archive, but the added safety should be weighed against the increased cost. Including the location of the repository on maps would help to conserve the information. Storing the nuclear waste information both in a national archive and in a common international nuclear waste archive may be a means to ensure long term conservation of the information.

Markers may be complementary to off-site achieves in initiating a search for the achieves. Markers cannot carry much information, but they are more assessable. However, even if markers survive, to be effective they must be perceived and correctly interpreted. As time passes, the likelihood of the message being effective will decline because of loss of memory and of cultural changes. The option of not marking the site has also been discussed, but rejected. In contrast, it is recommended that markers should be considered in an information conservation strategy.



Information conservation is indeed sensitive to the transfer of cultural heritage between generations. Factors like the legal support for the public's access to information, the information transfer in school teaching and the possible occurrence of legends and myth may play an important role.

■ Archive media

For the long term conservation of information also the longevity of the archive media is a crucial issue. Even today the two main alternatives are paper and microfilm. In the future other media, such as metal and ceramics may prove to be superior alternatives, but such media are not used today and their long-term properties are unknown.

Generally, hand-made paper not containing wood pulp can be regarded as permanent for more than 1000 years. The longevity of wood pulp paper is much less, and different standardization efforts are underway to develop a durable wood pulp paper. Still a longevity similar to old paper cannot be expected.

The lifetime of microfilm has been estimated to around 200 years. As the film may be copied four times, without significant loss of information, information on microfilm may be preserved for 1000 years, provided that a proper copying scheme is implemented.

The techniques for information storage will develop substantially between the present and the time for repository closure. Consequently, it is not meaningful to formulate detailed recommendations regarding media that should be used at that time. At the present the multi-copy paper used widely in the Nordic countries in combination with accepted copiers and printers is considered adequate, so today there is no reason for a large-scale transfer of information from paper to any other archive medium.

Cleanup of large radioactive contaminated areas and disposal of the generated waste (KAN-2)

■ Objectives

A severe accident at a nuclear power plant may result in a wide scale contamination of the environment. If contaminated areas are cleaned, large amounts of radioactive waste with varying activity content will be generated. The objective of the KAN-2 project was

- to estimate the amounts and activity concentrations in a variety of cleanup waste
- to experimentally study removal and disposal of soil
- to experimentally study the use of concrete for contaminated soil and barriers in disposal facilities
- to estimate costs and perform cost-benefit analyses and decision analyses for different cleanup and disposal measures

A literature survey worked out in the project shows that considerable experience is available from cleanup, management and disposal of cleanup wastes after nuclear accidents.

■ Estimation of amounts and activity concentrations

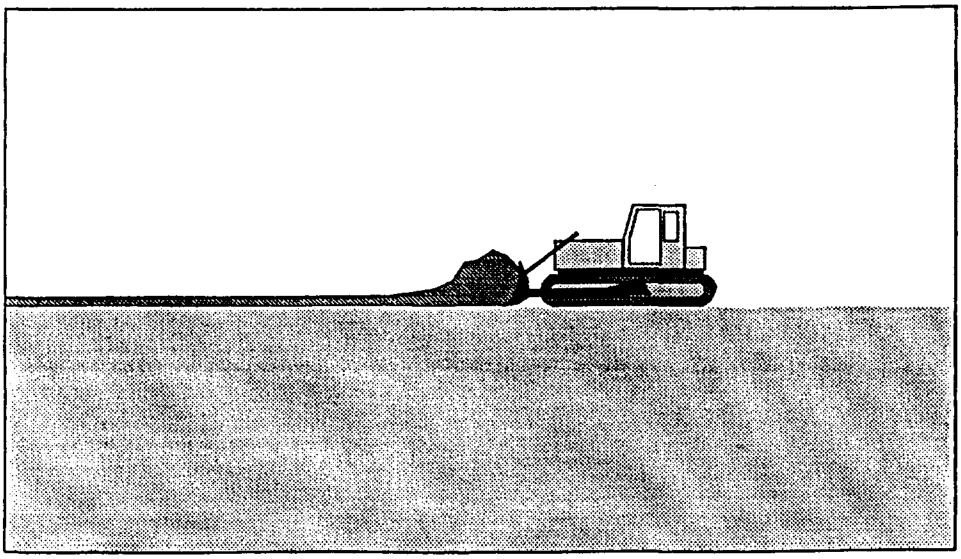
In order to calculate the amounts and activity concentrations a hypothetical accident, describing a worst case was used. The resulting cleanup waste is estimated for cleanup of urban, forest and agricultural areas.

If the cleanup is made soon after deposition it is important whether the deposition took place during rain or in dry weather conditions. In the latter case more of the activity will be retained in vegetation and on upper surfaces such as roofs. Vegetation will represent the bulk of the waste from forest areas. If the trees are cut soon after fallout most of the radioactivity can be removed, but the generated volumes will be very high. Effluents from firehosing walls, streets and other paved areas in urban areas will also be considerable.

In the long term, removed contaminated soil will represent the most voluminous and active waste from urban, forest, as well as from agricultural areas. Radionuclides migrate slowly in soil, and they are retained in the upper soil layer.

■ Experimental studies of removal and disposal of soil

It would be advantageous to minimize the volume of removed contaminated soil by only removing the uppermost layer of a few centimeters. Therefore a variety of earth moving machinery has been tested for this purpose in Northern Norway. The performance depends upon many factors such as type of soil, soil moisture and weight of the machinery. At present, no machine appears to suit all conditions.



■ Use of concrete for contaminated soil and barriers in disposal facilities

Experimental work has been carried out for studying the use of concrete for solidification of contaminated soil and to improve barriers in disposal facilities. Also the influence on migration of decaying organic materials present in soil was studied. An additive which allows for solidification of soil with rather low cement ratio was tested. However, it turned out that the leaching of Cs and Sr could not be retarded. Compared to clay, concrete also appears to have less favourable barrier properties. Also, organic products such as vegetation in cleanup wastes, may enhance the radionuclide migration and is thus unfavourable.

■ Cost-benefit analyses and decision analyses for different cleanup and disposal options

The costs of various cleanup measures as well as of transportation and final disposal of cleanup waste have been calculated, considering three different disposal options: shallow ground trenches, surface mounds and disposal in a natural valley. Shallow ground disposal was found to be somewhat more expensive than the surface mound option, whereas disposal in the natural valley is much more expensive. Which alternative is radiologically preferable was not studied in detail.

A cost-benefit analysis for different cleanup options in urban areas shows the cost for cleaning roofs, walls, streets, trees and gardens as compared with the dose reduction factors obtainable. The transportation and final disposal costs amounted to 5% of the overall costs for roofs, 13% for walls and around 30% for streets and trees. The analysis made for wet deposition revealed that decontamination of gardens should be given first priority and street cleaning second priority. Following dry deposition it is also cost-effective to cut trees.

Remediation of forests have so far only been studied in a rather limited manner. It has usually been assumed that cleanup of forest areas is not worthwhile. In the KAN-2 project a comprehensive study of the techniques, demands of costs and labour as well as the amounts of generated cleanup waste is described. The data collected were utilized in a decision analysis for a contaminated forest area. According to this study, some remedial actions look rather reasonable. For example, it may be justified to remove contaminated vegetation and soil from the most contaminated areas and to control access to rather large areas of the contaminated forest.

Climatological processes of importance for the long term stability of a repository for radioactive waste (KAN-3)

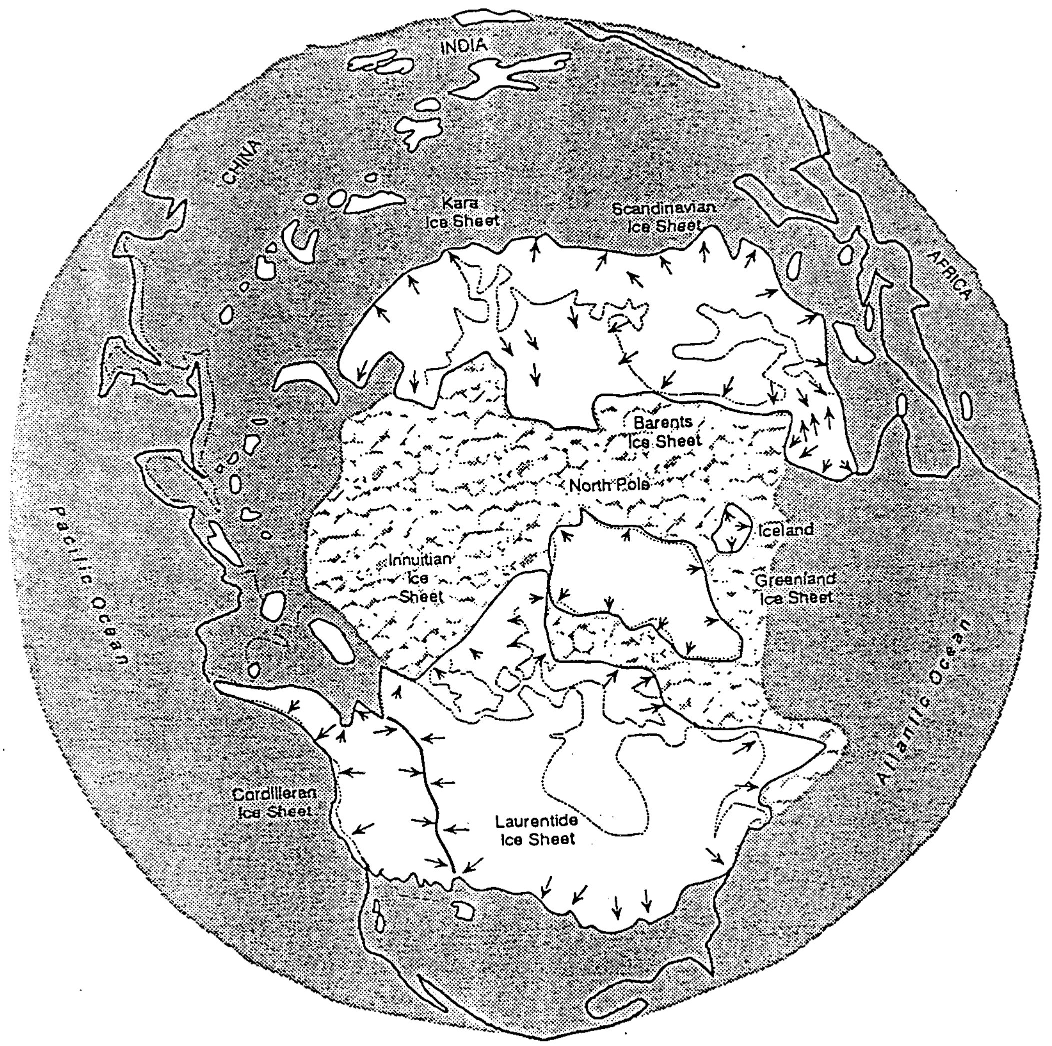
▪ Objectives

The aim of the project is to identify climate induced processes or events which can affect the integrity of a final repository for nuclear waste. The general objective of the project is to present the state of art concerning climate change processes. Certain questions that are needed in a safety assessment are also investigated, to help to demonstrate that the chosen concept of a final repository is dimensioned to withstand processes induced by climatic changes.

The implications of climatic change effects have been addressed in several comprehensive studies in the Nordic countries of the long term performance of nuclear waste repositories located deep in crystalline rock. Most of the research performed within the KAN-3 project is strongly coupled to these studies.

▪ Climatic changes in the past and in the future

Climatic changes have repeatedly occurred throughout the geological history. It is very likely that climatic changes (e.g. ice ages, permafrost etc) also will occur during the long future time span considered for the disposal of high level radioactive waste. Future climatic change will not only affect the biosphere but also the barriers (e.g. rock mass and engineered barriers), which may change todays barrier characteristics with respect to radionuclide movement.



Glaciated regions of the Northern Hemisphere during the last ice age. The arrows indicate the main directions of ice flow. The extent of sea ice covering the Arctic Ocean was much larger than at present and the world sea level around 100 m below the present level (Skinner & Porter 1987).

Ice ages during the earths history are reviewed with special emphasis on the last 2.5 million years. A theoretical model of future climate evolution is also presented. This model implies that large parts of Scandinavia will be glaciated three times in the coming 125,000 years. This information forms the basis when formulating glaciation scenarios.

■ Past shore lines as a means for identifying effects of glaciation

In Fennoscandia significant land uplift has taken place due to recovery of the earth's crust from the load of large ice sheets from the last glaciation. Remnants of past shore lines during different phases since the last glaciation can thus be observed on land.

If irregularities in past shore lines can be identified, this can help to identify postglacial movements along extensive fracture zones (*faults*) which might damage a future repository. A compilation of shore line data has been performed in Sweden, Norway and to a certain extent in Finland. The same type of database is used in all countries. This means that future analysis of shore displacement data will be easier to perform. As a case study in nature, possible postglacial traces have been searched on a line from southwestern Värmland to Norway.

■ Dating of faults as a means of exploring postglacial movements

Coupled to the analysis of postglacial movements is also the ability to conduct direct dating of faults. A review and a test of available and relevant direct dating techniques on faults has been performed within the project.

■ Permafrost

Permafrost can have a major influence on the recharge and discharge of groundwater, and could be significant in localizing places of return of radionuclides to the biosphere. Calculations demonstrate that permafrost in theory could develop to depths in excess of 500 m. This may have implications on the choice of repository depth, and further analyses are therefore motivated.

■ Modelling of glaciations

Two time-dependent, thermomechanically coupled three dimensional models have been developed in order to model an ice sheet behaviour. The different approaches have been used for the modelling of the last glaciation as a test of the models against the geological record of the past (Weichselian glaciation).

The response of the rock mass to glaciation, to thermal loading and to seismicity has been modelled numerically. The fault deformations caused by glaciation are significantly influenced by the initial stress conditions. The thermal loading and earthquake response cause deformation of faults and are likely to influence the groundwater flow.

Appendix: The KAN-programme

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References

Each of the NKS waste projects outlined in this summary is documented in its own final report issued by the Nordic Council of Ministers. For a more thorough description of the work carried out the reader is urged to explore these documents which are issued in the first part of 1994.

Tryk: Grafisk Service, RISØ

The Nordic Committee for Nuclear Safety Research - NKS organizes pluriannual joint research programmes. The aim is to achieve a better understanding in the Nordic countries of the factors influencing the safety of nuclear installations. The progamme also permits involvement in new developments in the nuclear safety, radiation protection, and emergency provisions. The three first programmes, from 1977 to 1989, were partly financed by the Nordic Council of Ministers.

The 1990-93 Programme comprises four areas:

* Emergency preparedness	(The BER-Programme)
* Waste and decommissioning	(The KAN-Programme)
* Radioecology	(The RAD-Programme)
* Reactor safety	(The SIK-Programme)

The programme is manages - and financed - by a consortium comprising the Danish Emergency Management Agency, the Finnish Ministry of Trade and Industry, Iceland's National Institute of Radiation Protection, the Norwegian Radiation Protection Authority , and the Swedish Nuclear Power Inspectorate.

Additional financing is offered by the IVO and TVO power companies, Finland, as well as by the following Swedish organizations: KSU, OKG, SKN, SRV, Vattenfall AB, Sydkraft AB, SKB.

Additional information is available from the NKS Secretary general, POB 49, DK-4000 Roskilde, fax (+45) 46 32 22 06